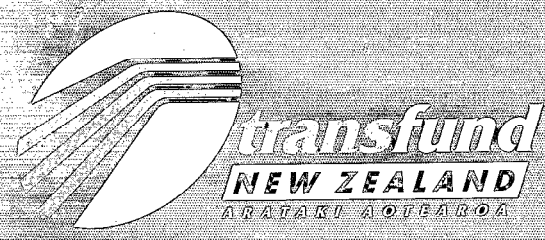

TRANSFUND NEW ZEALAND

DEVELOPMENT OF A SAFETY PERFORMANCE INDEX FOR SAFETY AUDIT OF EXISTING ROADS

DISCUSSION DOCUMENT AND PEER REVIEW

Review and Audit Division
Report No. RA97/640S

Report No. RA97/640S 600-06-17

TRANSFUND NEW ZEALAND

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DISCUSSION DOCUMENT AND PEER REVIEW

May 1998

PREFACE

This Report

This report contains a contract report plus a peer review of it. Transfund commissioned Opus International Consultants Ltd, Palmerston North to undertake a scoping study and then commissioned Beca Carter Hollings and Ferner Ltd, Auckland to undertake a peer review of Opus' report. Both are reproduced here.

The purpose of producing this report is to provide documentation of this pioneering work. This report is intended only for those with a genuine interest in following the development of the methodology. It will not be publicised widely, but will be made available on request.

Transfund is not bound by anything in this report. It does not necessarily agree with its contents.

Background

Since February 1995, Transit New Zealand and now Transfund New Zealand has been developing a methodology for the safety audit of existing roads. Transit reported the early work in its reports RA95/434S "Safety Audit of Existing Roads. Review of Process Development and Initial Implementation" and RA95/463S "Safety Audit of Existing Roads. Draft Procedures. February 1996".

Reports as Performance Measures

The reports of these audits make a number of recommendations and each recommendation has a risk rating assigned to it. Transfund's Review and Audit Manager, Peter Wright, proposed that these audit reports might be used as measures of the performance of the road controlling authorities whose roads were audited. The performance measure might be based on the number of recommendations made and their risk ratings. In this way, the performance of different authorities might be compared, and the performance of an authority over time might be measured.

Some potential problems were immediately obvious. These were:

- The audits are conducted teams of three or four people. There is no guarantee that one team will arrive at exactly the same conclusions as another team might.

- The risk ratings assigned to each recommendation are not based on objective data. They are subjective judgements. Again, there is no guarantee that one team will make the same judgements as another.

- The way the audit reports are written is crucial. Some teams might group four recommendations into one, while another team might leave the same four recommendations as four.

The Scoping Study

Despite these potential problems, Transfund commissioned a scoping study to explore the feasibility of using these audit reports as performance measures.

We consider that the results of the scoping exercise, reported here, are sufficiently encouraging to warrant further work. At the time of writing this preface, terms of reference for the continuation of this work are being drafted. They are likely to include:

- The creation of database of report recommendations and risk levels. The purpose of the database will be to give guidance to future audit teams on the combined wisdom of past teams. The database should be able to provide an "average" risk level for certain features or deficiencies;

- The definition a fixed format for report writing. This will ensure consistency of framing recommendations; and

- The continuation of the development of the performance measures taking into account the findings of the peer review.

Feedback

If readers have any comments on the methodology and its development described in this report, then please send them to:

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23rd April 1998

OPUS
INTERNATIONAL
CONSULTANTS

Development of a Safety Performance Index for Safety Audits on Existing Roads

Discussion Document

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Contents

Executive Summary

This report introduces safety performance measures to enable comparison between safety audits. The safety performance measures could be used to enable a road controlling authority to compare its performance on successive audits and to compare its performance against other road controlling authorities.

A safety performance index SPI is proposed, where:

$$SPI=[\sum RW].E$$

and the *risk weighting* RW are:

Risk Level	Low	Medium	High	Urgent
RW	1	10	100	750

and the *exposure* E= 1.00

Exposure for Safety Audits is defined as the length of time a road network is "exposed" to a Safety Audit team. This should not be confused with the project evaluation manual definition for exposure.

A *safety performance ratio* was developed as a method of directly gauging the performance of a road controlling authority against other authorities that have been audited in that year. A *safety performace ratio* SPR is proposed, where:

$$SPR=\frac{SPI}{675}$$

$$SPR=\frac{SPI}{675}$$

The above equation is based on the average safety performance index for 1996 being 675. This figure may be adjusted in future years following the completeion of additional safety audit reports.

Safety performance ratios above 1.00 indicate poorer than average performance. Values less than 1.00 indicate a better than average performance.

1. Introduction

1.1 A meeting of Safety Auditors was held by Transfund New Zealand on 10 December 1996 to discuss standard report formats for Safety Audits on existing roads. It was agreed at this meeting that a *safety performance index* be developed to summarise the findings of safety audits undertaken for road controlling authorities. The *safety performance index* could be used to enable a road controlling authority to:

- compare its performance on successive reviews
- compare its performance against other road controlling authorities

1.2 The *safety performance index* proposed is based on the number of safety problems made in a safety audit report, times the assessed level of risk attributed to each safety problem. The *safety performance index* for an individual report can then compared with the *safety performance index* of other safety audit reports to measure how well an authority is performing.

2. Objective

2.1 The objective of this report is to establish a Safety Performance Index, enabling a comparison to be made between safety audits of existing roads.

2.2 The Safety Performance Index will:

- enable a road controlling authorities performance to be compared in successive audits,
- enable a road controlling authority performance to be compared against the performance of other similar authorities,
- be robust enough to withstand the personal influence of individual audit teams and their assessment of risk,
- be adaptable to changes and development of safety auditing procedures,
- be simple to comprehend and use, for auditors and the target audience,
- be a fair and meaningful representation of the road controlling authorities safety performance,
- be suitable for use by state highway regions, rural road controlling authorities and urban road controlling authorities, and
- will comply with Transfund New Zealand Safety and Economic Assessment guidelines and philosophy.

3. Methodology

3.1 The *safety performance index* SPI is defined as:

$$SPI=[\sum RW].E$$

where RW is the *risk weighting* given to the safety problems identified during the aduit and

E is the *exposure* (or amount of time spent on the audit)

3.2 The development of risk *weighting* is discussed in Section 4. The development of *exposure* is discussed in Section 5.

3.3 The *safety performance index* provides a method by which a road controlling authority can use to measure its performance in successive safety audits or against published results from other audits. Further development of a database of reports will enable Transfund New Zealand to analyse trends in the Safety Performance Index over successive years.

3.4 To enable the *safety performance index* to be compared with other safety audits, a *safety performance ratio* SPR has been defined as:

$$SPR=\frac{SPI}{\overline{SPI}}$$

Where $\overline{SPI}$ is the *average safety performance index*

3.5 The *average safety performance index* is calculated from the total number of safety audits completed in previous years and it is proposed that it will be published annaully by Transfund New Zealand.

4. Risk Weighting

4.1 A *risk weighting* is a numerical value allocated to the apparent risk to road users of each safety problem.

4.2 The level of risk of each safety problem follows the four categories defined in Appendix III of Transfund New Zealand's "Safety Audit Procedures for Existing Roads, Draft Proceedures", as summarised below:

	Probability				
Severity	**Frequent**	**Probable**	**Occasional**	**Remote**	**Improbable**
Catastrophic	URGENT	HIGH RISK			
Critical			MEDIUM RISK		
Major				LOW RISK	
Minor					
Negligible					

Table : Safety Audit Risk Levels

4.3 Hazard probability is defined in the "Safety Audit Procedures for Existing Roads" as:

Probability	Description
Frequent	Likely to occur frequently (once/year)
Probable	Likely to occur more than once (once/5 years)
Occasional	Likely to occur at some time (once/10 years)
Remote	Will rarely occur (7-10 years)
Improbable	Unlikely that the occurrence may never be experienced

Table: Hazard Probability

4.4 Hazard severity is defined in the "Safety Audit Procedures for Existing Roads" as:

Category	Description
Catastrophic	Will cause multiple fatalities
Critical	Likely to cause a fatality
Major	Could possibly cause a fatality
Minor	Could cause serious injury
Negligible	Not likely to cause serious injury

Table: Hazard Severity

4.5 To enable the safety performance index to be calculated, we tested a range of *risk weightings* assigned to the various risk levels to determine a suitable set of weightings to be adopted for future audits,

4.6 The testing was completed using the findings of seven 1996 Transfund New Zealand safety audits. While it would have been desirable to use more reports, it was considered that the earlier audit reports were developmental and did not have the consistent format of the more recent reports.

4.7 Using the original safety audit on existing roads checklists, a list of safety audit items was used to prepare a risk weighting calculation sheet. The list was expanded to include additional common problems identified in the reports. (Refer to the *risk weighting calculation sheet* in Appendix E).

4.8 The calculation sheet recorded the general problems, assessed risk and cross references for each item identified in the safety audit report. The total *risk weighting* was calculated using the number of identified safety problems and not the number of recommendations. This is because some recommendations addressed two or more general problems.

4.9 *Risk weightings* were assigned to each safety problem based on the perceived risk to road users. The following range of tests *risk weightings* were used to trial the calculations, and test for sensitivity.

Risk level	Test						
	A	B	C	D	E	F	G
Low	1	1	1	1	1	1	1
Medium	2	4	6	8	10	10	10
High	5	10	25	50	75	100	100
Urgent	10	25	100	200	500	750	1000

Table : Test Values for Risk Weightings

4.10 We assumed low risk levels always had a *risk weighting* of 1. Test G, was determined from the Transit New Zealand Project Evaluation Manual ratio of accident costs where Fatal = Urgent Risk, Serious = High Risk, Minor = Medium Risk and Non Injury = Minor Risk.

4.11 Test F, used the Transit New Zealand adjusted severity cost for combined fatal and serious accidents for urgent risk. High, Medium and Low Risk were the same as test G.

4.12 Test A through to E where subjective assessments to test the sensitivity of the results. They were based on our opinions of possible relationships of *risk weightings*.

4.12 It is important that the finally selected range of *risk weightings* provide sufficient emphasis to the high risk and urgent safety problmes so as to encourage road controlling authorities to address those safety problems most likely to cause crashes. However, equally important is the need to not overlly penalise an authority when only one high risk safety problem is identified.

4.14 The results of the test *risk weightings* are summarised in Appendix B. They show that:

- The relative rankings (best to worst) of all authorities used in this study was independent of the risk weighting adopted.
- The test values F & G tended to exagerate the difference between audits.

4.15 The results of the testing must be treated with caution, however, as the results of the seven audits used in the above comparison do not contain a large number of high risk or urgent safety problems. Hence we chould not be too surprised that the different test *risk weighting* scenerios did not lead to different answers in this particular case.

4.16 In our opinion Test F or Test G are the preferred *risk weighting*, as they are based on existing Transfund New Zealand accident costings and reflect the importance placed on preventing serious and fatal accidents.

4.17 The higher ratings also give the auditor a numerical indication of the importance of the higher risk levels when assessing risk gradings for recommendations and may influence his decision on what risk level to apply to a problem.

4.18 Test *risk weighting* F provides the softer results for a urgent risk recommendation and it provides a better balance between a high number of "High" risk recommendations and one urgent recommendation.

4.19 We therefore recommend the adoption of test value F at this stage as it moderates urgent risk scores. However, this recommendation deserves further discussion before being finalised.

5. Exposure

5.1 For simplicity we have assumed that the *exposure* for each safety audit is the amount of time spent on each audit. It is the amount of time that the team is "exposed" to the road network. This should not be confused with the way it is used in the Transit New Zealand "Project Evaluation Manual". In the Project Evaluation Manual exposure it defined as the risk of having an accident measured by the number of vehicle kilometres travelling on a section of road per unit of time (year).

5.2 It is our view that all Transfund New Zealand audits of existing roads are the same. Each audit has a team of four people who travel a road network for 3 days, including 2 night drives. Each audit has introductory brief and an exit meeting. All of the seven audits involved Dr Ian Appleton, who provided a moderating overview of results. If we agree that this is constant, then each report is exposed to the same level of auditing, and in such cases the exposure for Transfund New Zealand safety audits of existing roads is 1.00.

5.3 In future however, exposure may vary depending on whether the audit is for an urban or rural area or is for periods shorter or longer than the standard 3 days.

6. Application

6.1 A draft paper "Procedures to Determine Performance Measures for Safety Audits on Existing Roads" in Appendix E has been prepared with a view to be included in the final "Procedures for Safety Audits on Existing Roads".

6.2 The Risk weighting calculation worksheet would be completed by the safety audit team leader and results discussed in the safety audit report. Explanation of *the safety performance index* and *safety performance ratio* would be required for the road controlling authority to understand the implications in terms of their road network.

6.3 Completing the worksheet could also serve as a final reminder of general issues relating to the audit that may have been overlooked. It may also provide guidance for listing the general recommendations in the report.

6.4 The *safety performance index* is proposed which provides an indication of the overall safety performance of a road controlling authority, and is given by:

$$SPI=[\sum RW].E$$

Where the *risk weightings* RW are:

risk level	risk weighting
Low	1
Medium	10
High	100
Urgent	750

And the *exposure* is to be taken (for the time being) as $E = 1.00$

6.5 The *safety performance ratio* is the ratio of the *safety performance index* to the average of the *safety performance index* for all of the safety audit reports, and is given by:

$$SPR=\frac{SPI}{675}$$

6.6 The above equation is based on the average safety performance index for 1996 being 675. This figure may be adjusted in future years following the completeion of additional safety audit reports.

6.7 A *safety performance ratio* above 1.00 indicates poorer performance compared to average. Below 1.00 indicates better than average performance.

6.8 Benefits of these calculations are:

- They fit in well with work to date on the draft safety audit on existing road procedures (ie. numerical risk weightings for assessed risk levels).
- The *risk weightings* quantify the relative importance of risk to road users of a safety problem and hence importance.
- The results can be expanded to include future reports without affecting the performance of previous years.
- A average *risk weighting* for each safety problem can be assessed giving guidance to auditors when assessing risk levels.
- The Risk Weighting Calculation Sheet is relatively easy to use and can also be used as a prompt list for the auditor as a check as they write the report.
- The proceedure can be extended to include safety audits which are longer or shorter than the standard 3 day audits.
- The results appear to be meaningful and can be analysed and commented on easily. (Refer to Section 7 : Discussion of Results).

6.9 Disbenefits of the process are:

- The results still depend on auditors opinion of safety issues and risk assessment. Though this may be reduced by publishing results and through Dr Ian Appleton's continuing overview of audit results.
- The initial sample of 7 projects is not big enough to establish a true population mean. This would take several years to achieve.

6.10 One of the limitations of the above proposed safety performance index is that it does not include emphasis or apply weight to areas of New Zealand that are most likely to benefit from improved safety. It is clear that a urgent safety problem is more important (in terms of resucing crashes) if it is on SH1 than if it is located on a low volume rural road. While the proposed method could be further developed to incorporate this, it is considered to be beyond the scope of this present study.

6.11 A further limitation of the proposal is that it does not recognise that the topography varies significantly throughout the country. It is clear that areas with hilly or mountainous terrain are likely to have significantly more safety problems than areas with a flat terrain. Similar differences will occur with urban and rural areas. It maybe possible to adjust the safety performance index in the future to account for these effects. However, more audit reports will be required before thse adjustments can be made.

7. Discussion of Results

7.1 Based on test value F, the following results were obtained from the calculations (refer Appendix C & D).

Audit	Number of General Items	Average Risk Weighting	Safety Performance Index	Safety Performance Ratio
East Waikato (SH)	23	39.39	906	1.08
Northland (SH)	25	16.48	412	0.45
Central Otago (SH)	17	10.53	179	0.29
Rodney	18	54.11	974	1.49
Auckland	18	70.11	1262	1.93
Manakau	15	20.20	303	0.56
Christchurch	14	49.29	690	1.36
Total Population	130	36.35	675	1.00
Standard Deviation	N/A	N/A	3965	0.61

Table : Summary of Test Value C Results

7.2 From the results the following general observations can be made:

- Central Otago (SH) had the best overall *safety performance index* and *safety performance ratio* due to the low number of items identified with low average risk weighting.
- Manukau City also had lower overall scores and was the best of the urban results.
- Auckland City had the poorest overall *safety performance index* due to the higher than average number of items identified with high and urgent risk weightings.
- Northland and State Highways did have a high number of items identified, but the risk weighting for each item was very low. This resulted in a good overall *safety performance index.*
- Christchurch City had a low number of problems with high average *risk weightings*, resulting in a higher than average *safety performance index.*
- Rodney District had poor *safety performance index* due to a high number of problems identified with average weighting. Rodney did record a urgent score for not safety auditing projects.
- East Waikato recorded a high number of items with low *risk weighting* resulting in a *safety performance ratio* about the average.

7.3 Analysis of the results of all seven audits can give an indication to average *risk weighting* for each item identified in an audit (refer the graphs in Appendix D). The first graph in Appendix D provides the national average *risk weighting* for each item plus how many times each item was recommended in the

seven 1996 reports. The following patterns can be identified:

- problems with the urban/rural interface were identified 5 times with an average *risk weighting* of 5 (low to medium risk).
- problems with warning signs where identified with an average *risk weighting* of 11 (medium risk).
- problems with destination signs where identified 6 times with an average *risk weighting* of 3 (low risk).
- problems with lighting were identified six times with an average *risk weighting* of 34 (medium to high risk).
- problems with advertising were identified five times with an average *risk weighting* of 44 (medium to high risk).
- the average *risk weighting* for the population is 36 based on 130 identified items.

7.4 Further study of the database may lead to identification of national issues requiring attention or information to aid auditors in assessing risk levels and hence *risk weightings*.

7.5 The values and results will become more reliable as the database is expanded. Adding more reports to the database will not effect the *safety performance index*.

7.6 The graphs can be used as a management tool to assist roading managers to practise safety and determine areas of weakness in comparison with national results. The identified problems for each roading authority can be compared to the national average for each item. For example, hazard marking or the application of destination signs.

8. Recommendation

8.1 It is recommended that a *safety performance index* SPI be adopted, where:

$$SPI=[\sum RW].E$$

and the *risk weightings RW* are:

risk level	Low	Medium	High	Urgent
RW	1	10	100	750

and the *exposure* E= 1.00

8.2 It is also recommended that a *safety performace ratio* SPR be adopted, where:

$$SPR=\frac{SPI}{675}$$

8.3 It is further recommended that:

- this report be peer reviewed and refined
- the revised report be circulated to a sample of safety audit team leaders and affected parties of safety audits on existing roads for their comment

References

1. Safety Audit of Existing Roads: Draft Procedures: Transit New Zealand Feb 1996.
2. Draft Report: Safety Audit of Existing Roads Auckland City: November 1996.
3. Draft Report: Safety Audit of Existing Roads Rodney District: December 1996.
4. Draft Report: Safety Audit of Existing Roads State Highways: East Waikato: September 1996.
5. Draft Report: Safety Audit of Existing Roads Christchurch City: October 1996.
6. Safety Audit of Existing Roads: State Highways, Northland: November 1996.
7. Safety Audit of Existing Roads: Manukau City: November 1996.
8. Safety Audit of Existing Roads: State Highways: Central Otago: October 1996.

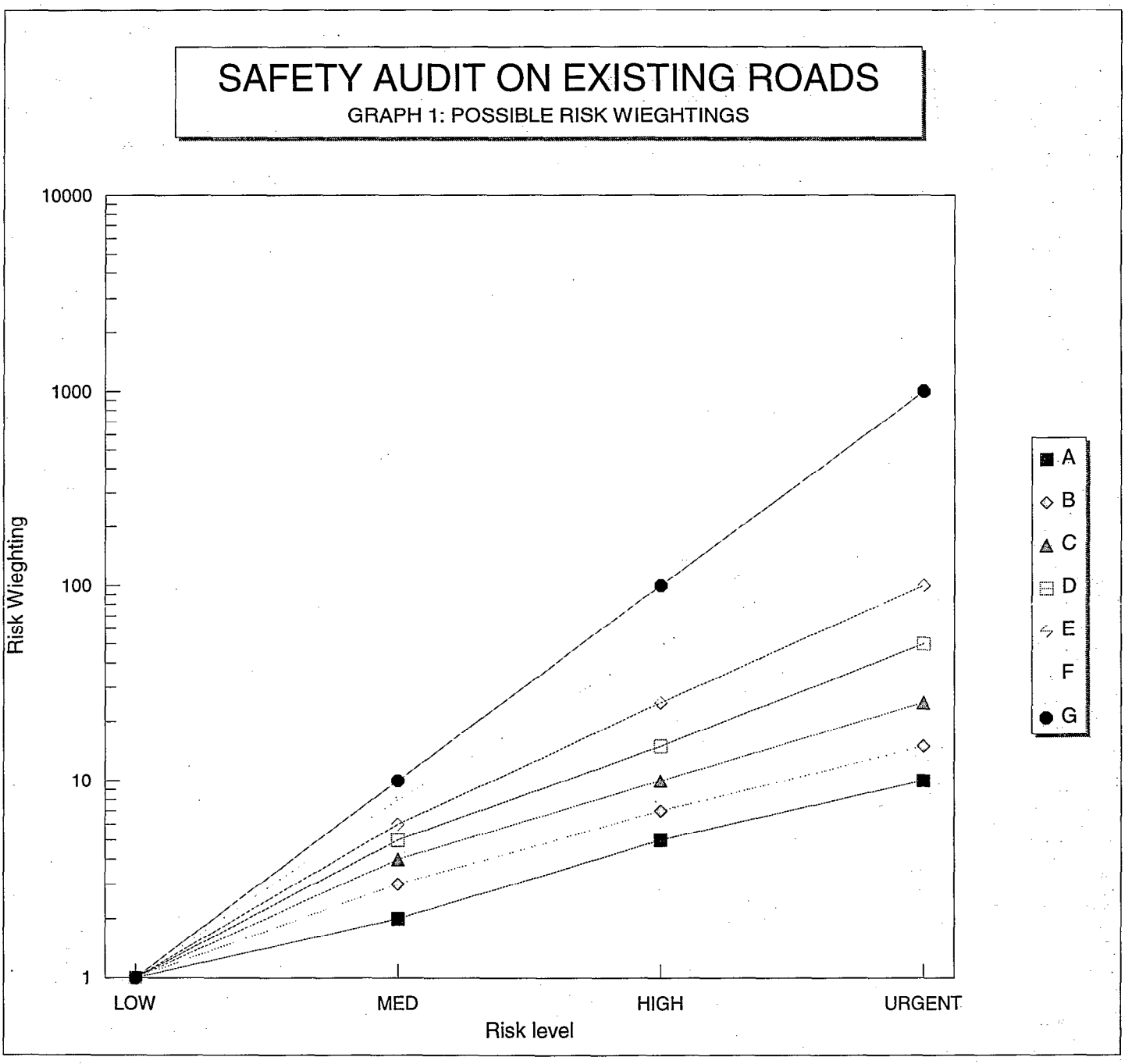
Appendices

APPENDIX A - Development of Risk Weightings

SAFETY AUDITS ON EXISTING ROADS

Posible Risk Weightings

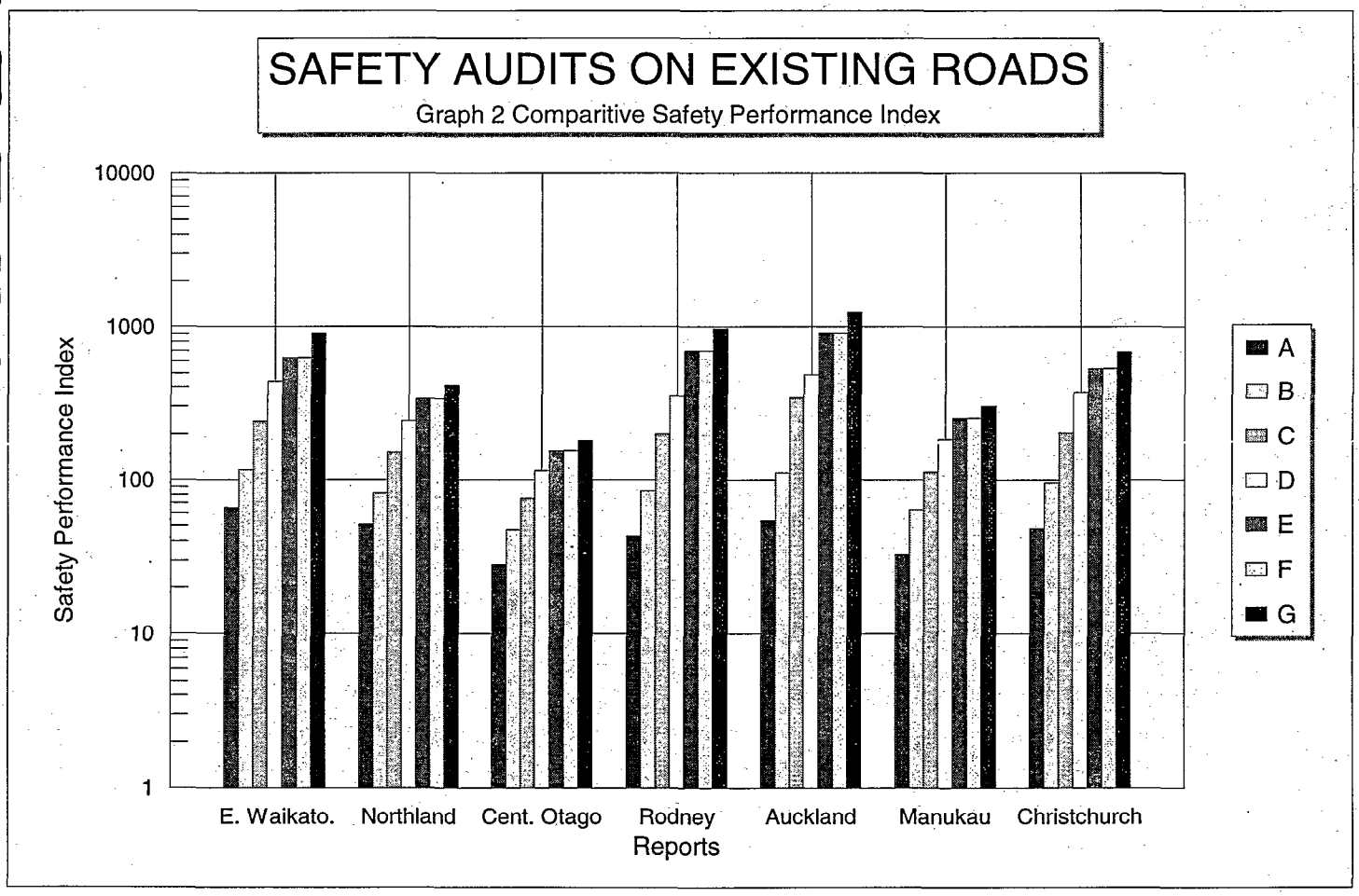
	A	B	C	D	E	F	G
LOW	1	1	1	1	1	1	1
MED	2	3	4	5	6	8	10
HIGH	5	7	10	15	25	50	100
URGENT	10	15	25	50	100	200	1000



APPENDIX B - Summary of Test Results

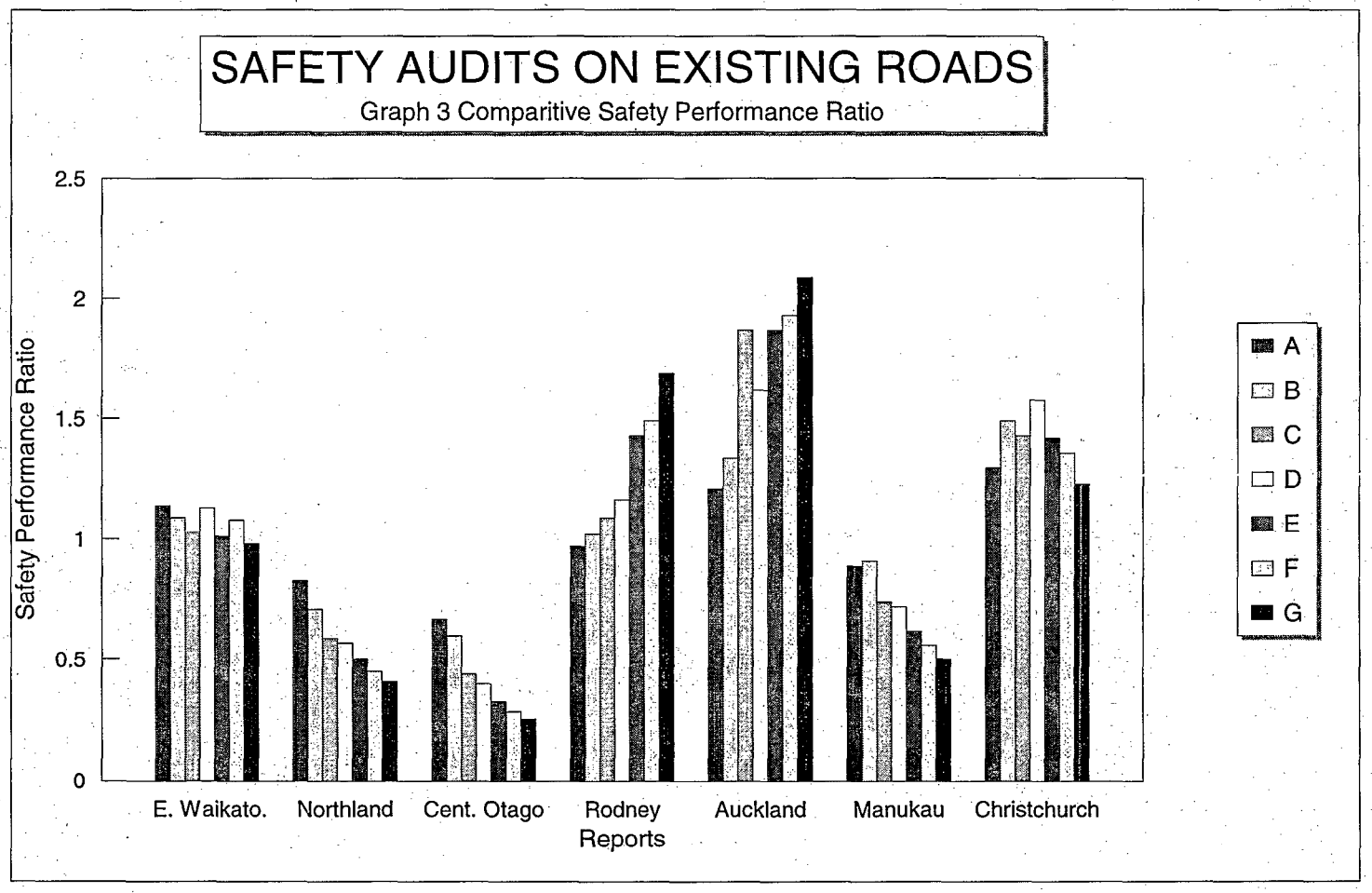
Safety Audits on Existing Roads
Comparison of results Safety Performance Index

	E. Waikato.	Northland	Cent. Otago	Rodney	Auckland	Manukau	Christchurch
Test A	65	51	28	43	54	33	48
Test B	116	82	47	85	111	63	96
Test C	241	151	76	201	343	113	204
Test D	436	242	115	352	490	183	372
Test E	631	337	154	699	912	253	540
Test F	906	412	179	974	1262	303	690
Test G	906	412	179	1224	1512	303	690



Safety Audits on Existing Roads
Comparison of results Safety Performance Ratios

	E. Waikato.	Northland	Cent. Otago	Rodney	Auckland	Manukau	Christchurch
Test A	1.14	0.83	0.67	0.97	1.21	0.89	1.30
Test B	1.09	0.71	0.60	1.02	1.34	0.91	1.49
Test C	1.03	0.59	0.44	1.09	1.87	0.74	1.43
Test D	1.13	0.57	0.40	1.17	1.62	0.72	1.58
Test E	1.01	0.50	0.33	1.43	1.87	0.62	1.42
Test F	1.08	0.45	0.29	1.49	1.93	0.56	1.36
Test G	0.98	0.41	0.26	1.69	2.09	0.50	1.23



APPENDIX C - Test Group F: Database and Full Results

Safety Audit on Existing Roads: Development of Safety Performance Index.
RISK LEVELS

			E Waikato	Northland	Cent. Otago	Rodney	Auckland	Manukau	Christchurch	total
1	Alignment /	Horizontal	0	0	0	0	0	0	0	0
	Environment	Vertical	med	high	0	0	0	0	0	2
		Urban/ Rural interface	low	low	low	med	0	med	0	5
2	Pavement Width	Lanes	0	0	0	0	0	high	0	1
		Shoulders	med	high low	low	0	0	0	0	4
3	Delineation	Warning signs	high	med	0	med med	med	0	med med med	8
		Information signs	low	0	0	low	0	0	0	3
		Regulatory signs	0	0	0	0	low	0	0	
		Destination signs	low	low	low	low	med	low	0	6
		Road name signs	0	low	0	med	med	low	med	5
		Hazard markings	0	med	med	0	urgent	0	0	3
		Edge marker posts	med med	low	med	high	0	0	0	5
		RRPMs	high	0	low	0	high	0	0	3
		Pavement Marking	0	0	0	med	med med	high	0	4
4	Level of Service	Overtaking opportunities	0	0	0	0	0	0	0	0
		Passing lanes	0	0	0	0	0	0	0	0
		Property access	0	0	0	med	0	med	0	2
		Speed Limits	0	low	0	0	med	0	0	2
5	Road Side Hazards	Advertising	low	med	med	0	high	0	high	5
		Clear zones	0	0	0	med	0	0	0	1
		Drains	med	high	0	0	0	0	0	2
		Poles/ objects	0	med	low	med	med	0	high	5
		Banks / cliffs	0	0	0	0	0	0	0	0
		Culverts	med	0	0	med	0	0	0	2
		Bridges	high	0	med	0	0	0	0	2
6	Intersections	Form	0	0	low	0	med	med med	med high	6
		Conspicuity	0	0	0	0	0	0	0	0
		Control	high	low	low	med	0	med	med	6
		Traffic signs	0	low low	0	low	0	0	0	3
		Markings	0	0	0	low	0	0	0	1
		Sight distance	0	med	0	0	0	0	med	2
7	Road users	Pedestrians	0	0	0	med	low med	med	0	4
		Cyclists	0	0	0	0	med	low	0	2
		Other	0	0	0	0	0	0	0	0
8	lighting		med	med	med	med	high	med med	med	8
9	Maintenance / General Works	Surface condition	med med high	med low med	med	0	0	0	med	8
		Shoulder condition	0	med	0	0	0	0	0	1
		Side slopes	0	0	0	0	0	0	0	0
		Clear zones	0	0	0	0	0	0	0	0
		Vegetation	0	low	low	0	0	0	0	2
		Guard railing	0	0	0	0	0	0	0	0
		Drainage	high	low	0	0	0	0	0	2
10	Maintenance/ signs and	Pavement markings	0	med	0	0	0	med	high	3
		RRPMs	low	0	low	0	0	0	high	3
		Edge marker posts	med	0	med	0	0	0	0	2
		Signs	low	0	0	0	0	0	0	1
11	Road works		high	0	high	0	high	0	0	3
13	Others: special		0	0	0	urgent	med	med	0	3
		Total	**23**	**25**	**17**	**18**	**18**	**15**	**14**	**130**

Safety Audit on Existing Roads: Development of Safety Performance Index.

RISK WEIGHTING COMPARISONS

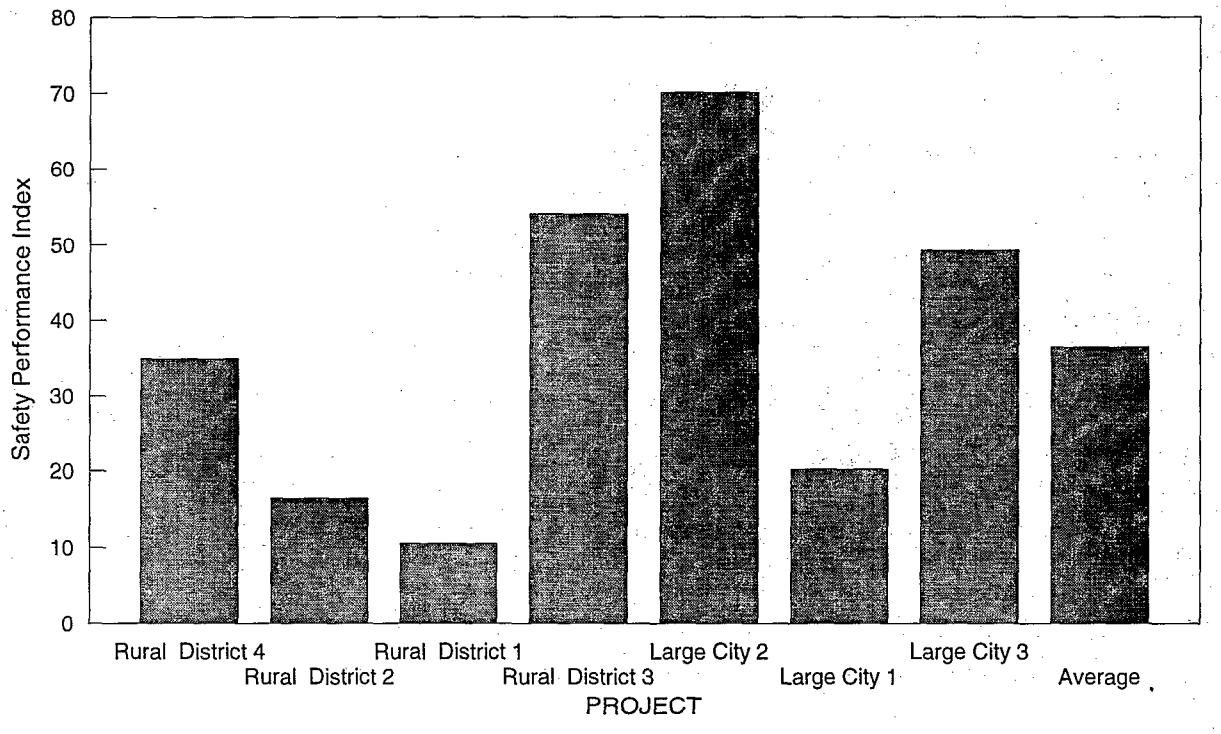
			1	2	3	4	6	7	8	total
			E Waikato	Northland	Cent. Otago	Rodney	Auckland	Manukau	Christchurch	
1	Alignment / Environment	Horizontal	0	0	0	0	0	0	0	0
		Vertical	10	100	0	0	0	0	0	110
		Urban/ Rural interface	1	1	1	10	0	10	0	23
2	Pavement Width	Lanes	0	0	0	0	0	100	0	100
		Shoulders	10	101	1	0	0	0	0	112
3	Delineation	Warning signs	100	10	0	20	10	0	30	170
		Information signs	1	0	0	1	0	0	0	2
		Regulatory signs	0	0	0	0	1	0	0	
		Destination signs	1	1	1	1	10	1	0	15
		Road name signs	0	1	0	10	10	1	10	32
		Hazard markings	0	10	10	0	750	0	0	770
		Edge marker posts	20	1	10	100	0	0	0	131
		RRPMs	100	0	1	0	100	0	0	201
		Pavement Marking	0	0	0	10	20	100	0	130
4	Level of Service	Overtaking opportunities	0	0	0	0	0	0	0	0
		Passing lanes	0	0	0	0	0	0	0	0
		Property access	0	0	0	10	0	10	0	20
		Speed Limits	0	1	0	0	10	0	0	11
5	Road Side Hazards	Advertising	1	10	10	0	100	0	100	221
		Clear zones	0	0	0	10	0	0	0	10
		Drains	10	100	0	0	0	0	0	110
		Poles/ objects	0	10	1	10	10	0	100	131
		Banks / cliffs	0	0	0	0	0	0	0	0
		Culverts	10	0	0	10	0	0	0	20
		Bridges	100	0	10	0	0	0	0	110
6	Intersections	Form	0	0	1	0	10	20	210	241
		Conspicuity	0	0	0	0	0	0	0	0
		Control	100	1	1	10	0	10	10	132
		Traffic signs	0	2	0	1	0	0	0	3
		Markings	0	0	0	1	0	0	0	1
		Sight distance	0	10	0	0	0	0	10	20
7	Road users	Pedestrians	0	0	0	10	11	10	0	31
		Cyclists	0	0	0	0	10	1	0	11
		Other	0	0	0	0	0	0	0	0
8	lighting		10	10	10	10	100	20	10	170
9	Maintenance / General Works	Surface condition	120	21	10	0	0	0	10	161
		Shoulder condition	0	10	0	0	0	0	0	10
		Side slopes	0	0	0	0	0	0	0	0
		Clear zones	0	0	0	0	0	0	0	0
		Vegetation	0	1	1	0	0	0	0	2
		Guard railing	0	0	0	0	0	0	0	0
		Drainage	100	1	0	0	0	0	0	101
10	Maintenance/ signs and	Pavement markings	0	10	0	0	0	10	100	120
		RRPMs	1	0	1	0	0	0	100	102
		Edge marker posts	10	0	10	0	0	0	0	20
		Signs	1	0	0	0	0	0	0	1
11	Road works		100	0	100	0	100	0	0	300
13	Others: special		0	0	0	750	10	10	0	770
		Risk weighting	**35**	**16**	**11**	**54**	**70**	**20**	**49**	**36**

SAFETY AUDIT ON EXISTING ROADS PERFORMANCE MEASURES

	Rural District 4	Rural District 2	Rural District 1	Rural District 3	Large City 2	Large City 1	Large City 3	Average	Standard
	1	2	3	4	6	7	8		Deviation
Average Risk Weighting	35.043	16.48	10.529	54.111	70.111	20.2	49.286	37	22.16
Number of problems	23	25	17	18	18	15	14	19	4.04
Safety Performance Index	906	412	79	974	1262	303	690	661	
Safety Performance Ratio	0.96	0.45	0.29	1.48	1.92	0.55	1.35	1.00	0.61

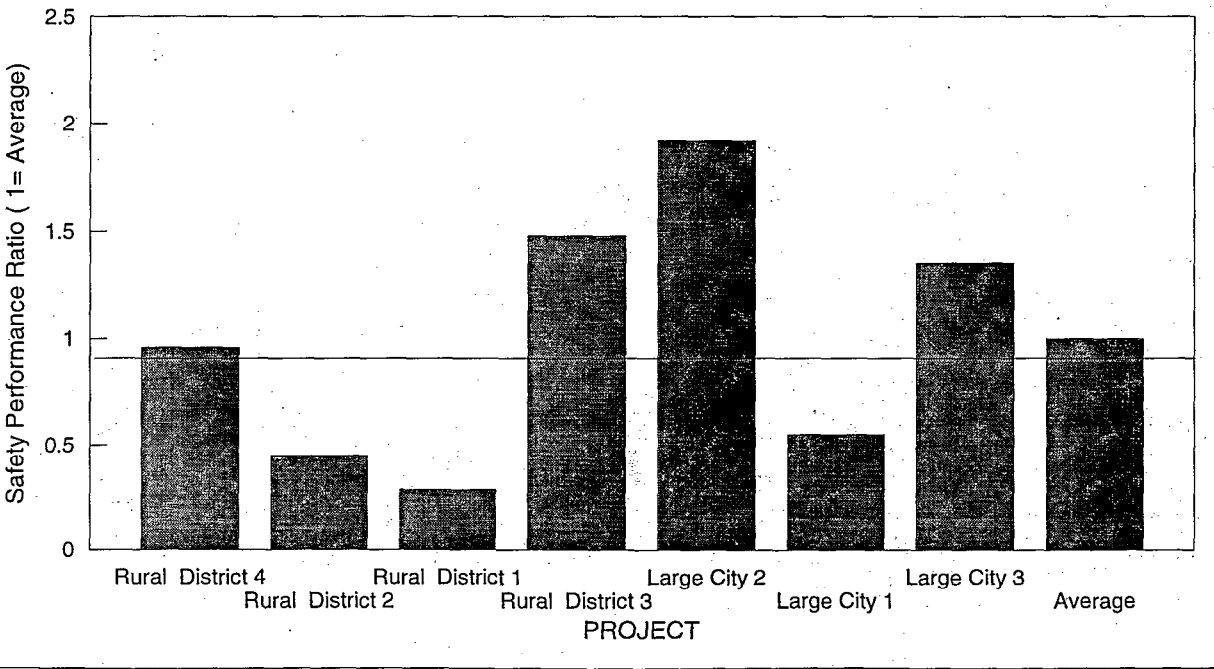
SAFETY AUDIT ON EXISTING ROADS

GRAPH 4 SAFETY PERFORMANCE INDEX



SAFETY AUDIT ON EXISTING ROADS

GRAPH 5 SAFETY PERFORMANCE RATIOS



Safety Audit on Existing Roads: Development of Safety Performance Index..

1 East Waikato State Highways

			Ref	Risk	RW	Notes
1	Alignment /	Horizontal				
	Environment	Vertical	4.1.1.1	med	10	EMP req. over vertical curves
		Urban/ Rural interface	4.2.9	low	1	Delineation though townships, 70 km/h zones
2	Pavement Width	Lanes				
		Shoulders	4.2.11	med	10	
3	Delineation	Warning signs	4.2.8	high	100	Curve warning signs
		Information signs	4.2.10	low	1	Passing lane signs
		Reglatory signs				
		Destination signs	4.2.12	low	1	Upgrade
		Road name signs				
		Hazard markings				
		Edge marker posts	4.1.1.2 4.1.1.3	med med	20	old standard layout,, Visibility oh type c on windy alignments
		RRPMs	4.3.1	high	100	RRPMs for RTB TNZ Policy
		Pavement Marking				
4	Level of Service	Overtaking opportunities				
		Passing lanes				
		Property access				
		Speed Limits				
5	Road Side Hazards	Advertising	4.2.3	low	1	unauthorised, reflective
		Clear zones				
		Drains	4.2.2	med	10	deep land drains
		Poles/ objects				
		Banks / cliffs				
		Culverts	4.2.4	med	10	mark or g/r concrete culverts
		Bridges	4.2.6	high	100	One lane bridge, visibility,signs,markings
6	Intersections	Form				
		Conspicuity				
		Control	4.2.1	high	100	install control
		Traffic signs				
		Markings				
		Sight distance				
7	Road users	Pedestrians				
		Cyclists				
		Other				
8	lighting		4.2.3	med	110	strategy to upgrade
9	Maintenance / General Works	Surface condition	4.1.4 4.1.6 4.1.7	med med high	120	Patching , flushing, sealing of unsealed sections
		Shoulder condition				
		Side slopes				
		Clear zones				
		Vegetation				
		Guard railing				
		Drainage	4.1.5	high	100	blocked drains
10	Maintenance/ signs and markings	Pavement markings				
		RRPMs	4.1.2	low	1	missing and worn
		Edge marker posts	4.1.1.4	med	10	damaged, dirty ,missing
		Signs	4.2.7	low	1	PW41.3 signs
11	Road works		4.1.3	high	100	poor signs
13	Others: special					
	Safety Performance Index		**906**			

Safety Audit on Existing Roads: Development of Safety Performance Index..

2 Northland State Highways

			Ref	Risk	RW	Notes
1	Alignment / Environment	Horizontal				
		Vertical	6.2.1	high	100	requires no overtaking lines
		Urban/ Rural interface	6.11.3	low	1	edgelines req (low), lighting(low), edge marker posts in 70 km/h zones(low)
2	Pavement Width	Lanes				
		Shoulders (narrow)	6.3.1	high low	101	Narrow shoulders: high on sh 1F(high), remaining highways (Low). Delineate wide shoulders(low)
3	Delineation	Warning signs	6.13.1	med	10	upgrade curve advisory signs (med) Upgrade chevrons (low)
		Information signs				
		Reglatory signs				
		Destination signs	6.16	low	1	implement strategy
		Road name signs	6.12.4	low	1	implement strategy
		Hazard markings	6.14.1	med	10	bridge end markers
		Edge marker posts	6.2.2	low	1	install extra on vertical curves
		RRPMs				
		Pavement Marking				
4	Level of Service	Overtaking opportunities				
		Passing lanes				
		Property access				
		Speed Limits	6.18.1	low	1	revise urban areas
5	Road Side Hazards	Advertising	6.19	med	10	policy restricting use
		Clear zones				
		Drains	6.6	high	100	deep side drains
		Poles/ objects	6.7.1	med	10	hazard mark
		Banks / cliffs				
		Culverts				
		Bridges				
6	Intersections	Form				
		Conspicuity				
		Control	6.17	low	1	install control on sideroads
		Signs	6	low low	2	advance warning signs(Low) RG signs visble from SH(low)
		Markings				
		Sight distance	6.8	med	10	restricted by vegitation
7	Road users	Pedestrians				
		Cyclists				
		Other				
8	lighting		6.12.5	med	10	upgrade in urban areas
9	Maintenance / General Works	Surface condition	6.4.1 6.4.2 6.4.3	med low med	21	high incidence of flushing (med), Poor pavement condition from geotechnical problems(low), Dirty sxurface from haulage (low)
		Shoulder condition	6.5.1	med	10	rutting in shoulders
		Side slopes				
		Clear zones				
		Vegetation	6.3.2	low	1	in front of signs
		Guard railing				
		Drainage	6.10.1	low	1	vegitation in drainage ditches
10	Maintenance/ signs and markings	Pavement markings		med	10	edge lines Shfted?
		RRPMs				
		Edge marker posts				
		Signs				
11	Road works					
13	Others: special					
	Safety Performance Index		**412**			

Safety Audit on Existing Roads: Development of Safety Performance Index..

3 Central Otago State Highways

			Ref	Risk	RW	Notes
1	Alignment / Environment	Horizontal				
		Vertical				
		Urban/ Rural interface	4.1.11	low	1	semi urban make urban
2	Pavement Width	Lanes				
		Shoulders (narrow)	4.1.10	low	1	install RRPMs on wide sealed shoulders
3	Delineation	Warning signs				
		Information signs				
		Reglatory signs				
		Destination signs	4.1.3	low	1	strategy to upgrade
		Road name signs				
		Hazard markings	4.14	med	10	Install Hazard markings and BEM on all bridges
		Edge marker posts	4.15	med	10	Additional req. on vertiacal curves
		RRPMs	4.1.1	low	1	install RRPMS on low volume highways
		Pavement Marking				
4	Level of Service	Overtaking opportunities				
		Passing lanes				
		Property access				
		Speed Limits				
5	Road Side Hazards	Advertising		med	10	Improve controlls in district schemes
		Clear zones				
		Drains				
		Poles/ objects	4.1.7	low	1	mail boxes hazard
		Banks / cliffs				
		Culverts				
		Bridges	4.1.4	med	10	strategy to install g/r
6	Intersections	Form	4.1.3	low	1	adopt constant layout to intersections
		Conspicuity				
		Control	4.1.3	low	1	install controll on all side roads
		Signs				
		Markings				
		Sight distance				
7	Road users	Pedestrians				
		Cyclists				
		Other				
8	lighting		4.19	med	10	strategy to upgrade lighting
9	Maintenance / General Works	Surface condition	4.2.3	med	10	frost heave
		Shoulder condition				
		Side slopes				
		Clear zones				
		Vegetation	4.1.8	low	1	remove saplings
		Guard railing				
		Drainage				
10	Maintenance/ signs and markings	Pavement markings				
		RRPMs	4.2.2	low	1	RRPMs, old, worn, missing
		Edge marker posts	4.2.1	med	10	posts missing/not enough
		Signs				
11	Road works		4.2.5	high	100	poorly delineated
13	Others: special					
	Safety Performance Index				**179**	

Safety Audit on Existing Roads: Development of Safety Performance Index..

4 Rodney District

			Ref	Risk	RW	Notes
1	Alignment / Environment	Horizontal				
		Vertical				
		Urban/ Rural interface	6.1	med	10	Consistant approach needed
2	Pavement Width	Lanes				
		Shoulders (narrow)				
3	Delineation			med	20	curve warning signs chevron boards
		Warning signs	6.4	med		
		Information signs	6.5	low	1	rest area/ motorists service
		Reglatory signs				
		Destination signs	6.3	low	1	install strategy
		Road name signs	6.2	med	10	strategy
		Hazard markings				
		Edge marker posts	6.4	high	100	inconsistant application
		RRPMs				
		Pavement Marking	a	med	10	consistant std req urban
4	Level of Service	Overtaking opportunities				
		Passing lanes				
		Property access	6.9	med	10	adopt standards that will suit traffic growth
		Speed Limits				
5	Road Side Hazards	Advertising				
		Clear zones	6.7	med	10	clear zone policy
		Drains				
		Poles/ objects	6.7, a	med	10	proximity to lanes mark hazards
		Banks / cliffs				
		Culverts	6.7	med	10	delineate or rail
		Bridges				
6	Intersections	Form				
		Conspicuity				
		Control	a	med	10	install on side roads of arterials main road
		Signs	6.6	low	1	req. advance warning
		Markings	6.6	low	1	inconsistant
		Sight distance				
7	Road users	Pedestrians	a	med	10	urban use, footpaths, bus shelters
		Cyclists				
		Other				
8	lighting		a	med	10	continue urban upgrade
9	Maintenance / General Works	Surface condition				
		Shoulder condition				
		Side slopes				
		Clear zones				
		Vegetation				
		Guard railing				
		Drainage				
10	Maintenance/ signs and markings	Pavement markings				
		RRPMs				
		Edge marker posts				
		Signs				
11	Road works					
13	Others: special		6.8	urgent	750	adopt safety audits for projects
	Safety Performance Index				**974**	

Safety Audit on Existing Roads: Development of Safety Performance Index..

5 Auckland City

			Ref	Risk	RW	Notes
1	Alignment / Environment	Horizontal				
		Vertical				
		Urban/ Rural interface				
2	Pavement Width	Lanes				
		Shoulders (narrow)				
3	Delineation	Warning signs	5.1.13	med	10	upgrade intensity of keep left signs
		Information signs				
		Reglatory signs	5.1.12	low	1	upgrade size of clear way signs
		Destination signs	5.1.4	med	10	install strategy
		Road name signs	5.1.8	med	10	upgrade
		Hazard markings	5.1.11	urgent	750	hazard markings on poles
		Edge marker posts				
		RRPMs	5.1.2	high	100	inconsistant application
		Pavement Marking	5.2 6	med med	20	mark c.ls on collector roads, Investigate lane markings/use in CBD sites
4	Level of Service	Overtaking opportunities				
		Passing lanes				
		Property access				
		Speed Limits	5.1.5	med	10	set approriate limits
5	Road Side Hazards	Advertising	5.1.14	high	100	control as per rts 7
		Clear zones				
		Drains				
		Poles/ objects	5.1.10	med	10	Relocate lighting columns when upgrading,
		Banks / cliffs				
		Culverts				
		Bridges				
6	Intersections	Form	5.1.1	med	10	upgrade signals to Austroads
		Conspicuity				
		Control				
		Signs				
		Markings				
		Sight distance				
7	Road users	Pedestrians	5.1.3	low med	11	inconsistant application markings ped crossings, Ped refuges to Austroads
		Cyclists	5.1.9	med	10	cycle ways for areas near schools
		Other				
8	lighting		5.1.10	high	100	Continue upgrade strategy,
9	Maintenance / General Works	Surface condition				
		Shoulder condition				
		Side slopes				
		Clear zones				
		Vegetation				
		Guard railing				
		Drainage				
10	Maintenance/ signs and markings	Pavement markings				
		RRPMs				
		Edge marker posts				
		Signs				
11	Road works		5.1.6	high	100	Ensure working on the road is met
13	Others: special		3(ii)	med	10	inconsistant standards adopted through out city
	Safety Performance Index		**1262**			

Safety Audit on Existing Roads: Development of Safety Performance Index..

6 Manukau City

			Ref	Risk	RW	Notes
1	Alignment /	Horizontal				
	Environment	Vertical				
		Urban/ Rural interface		med	10	revise treatments for urban speed change areas
2	Pavement Width	Lanes		high	100	lane management
		Shoulders (narrow)				
3	Delineation	Warning signs				
		Information signs				
		Reglatory signs				
		Destination signs	3.11.2	low	1	install
		Road name signs	3.11.1	low	1	upgrade
		Hazard markings				
		Edge marker posts				
		RRPMs				
		Pavement Marking		high	100	upgrade edge lines
4	Level of Service	Overtaking opportunities				
		Passing lanes				
		Property access	3.3	med	10	Control development access
		Speed Limits				
5	Road Side Hazards	Advertising				
		Clear zones				
		Drains				
		Poles/ objects				
		Banks / cliffs				
		Culverts				
		Bridges				
6	Intersections	Form	3.2 3.6	med med	20	poor roundabouts(med), upgrade signals to naasra
		Conspicuity				
		Control	3.8	med	10	install side road control on arterials
		Signs				
		Markings				
		Sight distance				
7	Road users	Pedestrians		med	10	reveiw facilities
		Cyclists		low	1	revise cycle route
		Other				
8	lighting		3.5	med med	20	Upgrade existing, install new.
9	Maintenance / General Works	Surface condition				
		Shoulder condition				
		Side slopes				
		Clear zones				
		Vegetation				
		Guard railing				
		Drainage				
10	Maintenance/ signs and markings	Pavement markings		med	10	poor remarks after repairs
		RRPMs				
		Edge marker posts				
		Signs				
11	Road works					
13	Others: special			med	10	adopt CRS measures along route
	Safety Performance Index				**303**	

Safety Audit on Existing Roads: Development of Safety Performance Index..

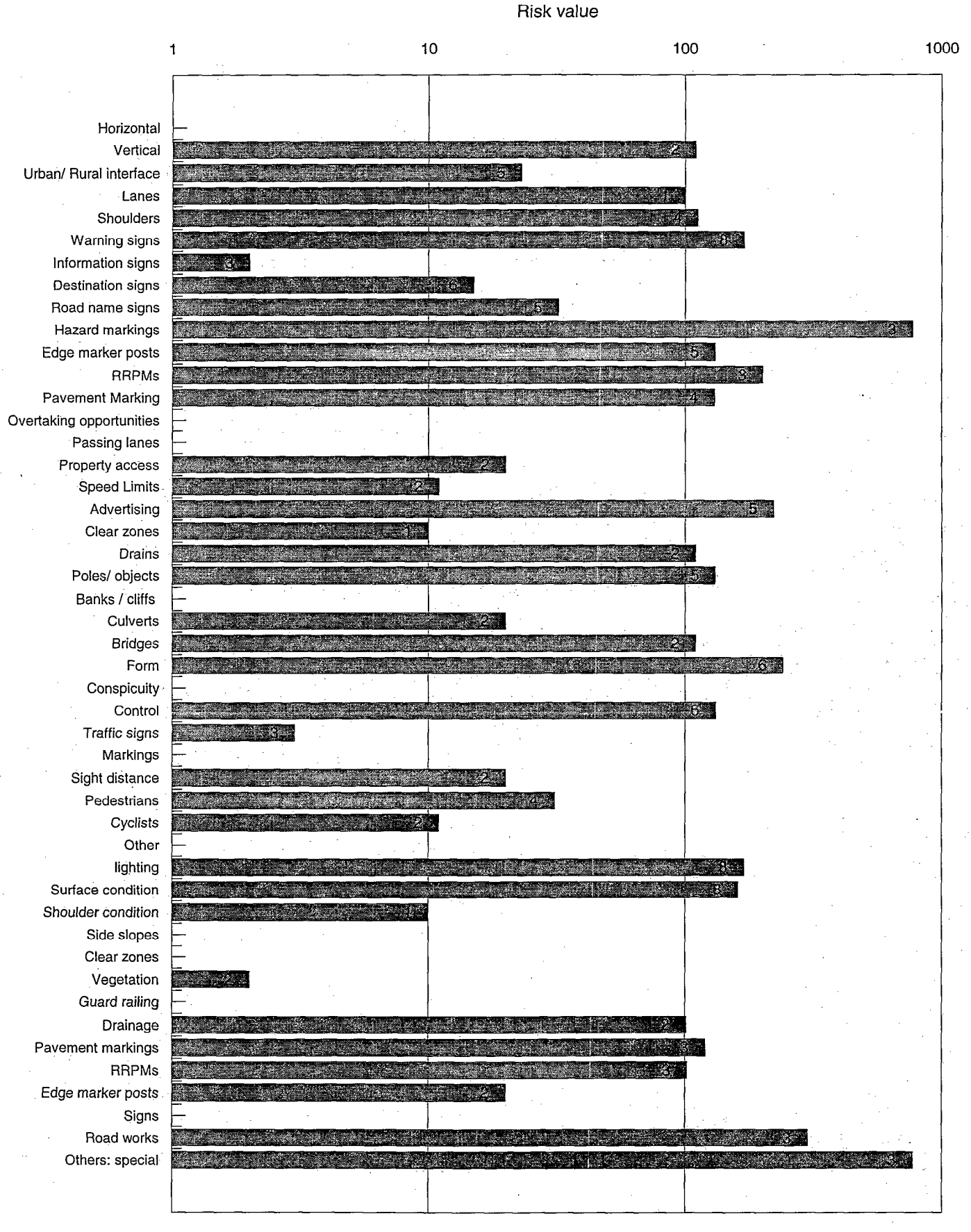
7 Christchurch City

			Ref	Risk	RW	Notes
1	Alignment / Environment	Horizontal				
		Vertical				
		Urban/ Rural interface				
2	Pavement Width	Lanes				
		Shoulders (narrow)				
3	Delineation			med		chevrons incorect,(med), PW11 Incorrect(Med)
				med	30	RG17 incorrect (med)
		Warning signs	3.11	med		
		Information signs				
		Reglatory signs				
		Destination signs				
		Road name signs	3.3	med	10	upgrade
		Hazard markings				
		Edge marker posts				
		RRPMs				
		Pavement Marking				
4	Level of Service	Overtaking opportunities				
		Passing lanes				
		Property access				
		Speed Limits				
5	Road Side Hazards	Advertising	3.6	high	100	Upgrade district scheme
		Clear zones				
		Drains				
		Poles/ objects		high	100	hazard mark poles
		Banks / cliffs				
		Culverts				
		Bridges				
6	Intersections			high		threshold colour same as footpath (priority)
				med	210	Upgrade signals to NAASRA(med) Upgrade
		Form	3.1 3.2	high		phasing(med)
		Conspicuity				
		Control	3.12	med	10	install side road on arterials
		Signs				
		Markings				
		Sight distance	3.7	med	10	parking limits visibility
7	Road users	Pedestrians				
		Cyclists				
		Other				
8	lighting		3.3	med	10	required on isolated sections
9	Maintenance / General Works	Surface condition	3.4	med	10	crack sealing
		Shoulder condition				
		Side slopes				
		Clear zones				
		Vegetation				
		Guard railing				
		Drainage				
10	Maintenance/ signs and markings	Pavement markings	3.4	high	100	poor maintenance
		RRPMs	3.4	high	100	poor maintenance
		Edge marker posts				
		Signs				
11	Road works					
13	Others: special					
	Safety Performance Index				**690**	

APPENDIX D - Comparison of Risk Weightings per Item per Road Controlling Authority

SAFETY AUDIT ON EXISTING ROADS

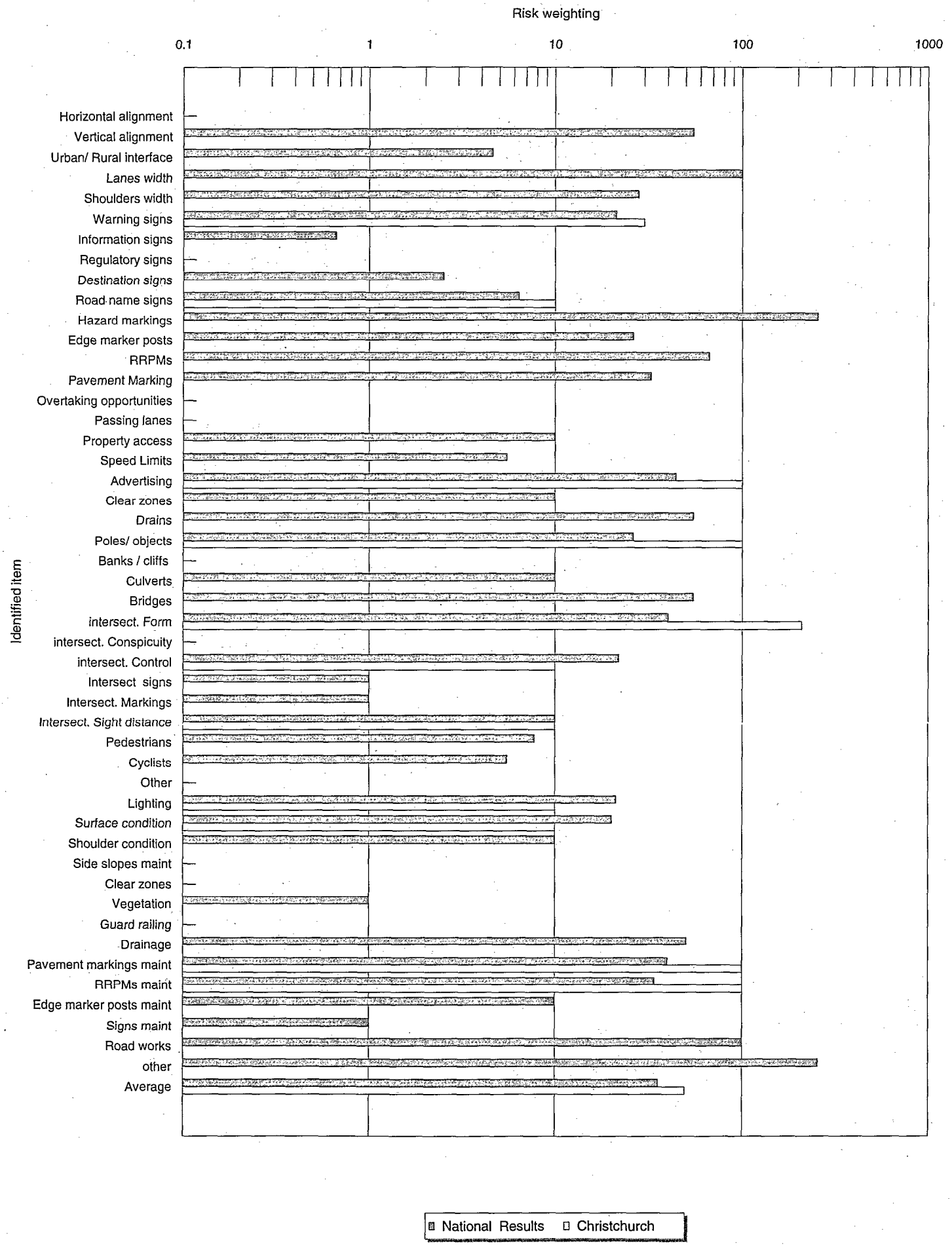
AVERAGE RISK WEIGHTINGS



	National Results			Christchurch
	total items	Total RW	Av. RW	RW
Horizontal alignment	0	0	ERR	0
Vertical alignment	2	110	55	0
Urban/ Rural interface	5	23	5	0
Lanes width	1	100	100	0
Shoulders width	4	112	28	0
Warning signs	8	170	21	30
Information signs	3	2	1	0
Regulatory signs	0	0	ERR	0
Destination signs	6	15	3	0
Road name signs	5	32	6	10
Hazard markings	3	770	257	0
Edge marker posts	5	131	26	0
RRPMs	3	201	67	0
Pavement Marking	4	130	33	0
Overtaking opportunities	0	0	ERR	0
Passing lanes	0	0	ERR	0
Property access	2	20	10	0
Speed Limits	2	11	6	0
Advertising	5	221	44	100
Clear zones	1	10	10	0
Drains	2	110	55	0
Poles/ objects	5	131	26	100
Banks / cliffs	0	0	ERR	0
Culverts	2	20	10	0
Bridges	2	110	55	0
intersect. Form	6	241	40	210
intersect. Conspicuity	0	0	ERR	0
intersect. Control	6	132	22	10
Intersect signs	3	3	1	0
Intersect. Markings	1	1	1	0
Intersect. Sight distance	2	20	10	10
Pedestrians	4	31	8	0
Cyclists	2	11	6	0
Other	0	0	ERR	0
Lighting	8	170	21	10
Surface condition	8	161	20	10
Shoulder condition	1	10	10	0
Side slopes maint	0	0	ERR	0
Clear zones	0	0	ERR	0
Vegetation	2	2	1	0
Guard railing	0	0	ERR	0
Drainage	2	101	51	0
Pavement markings maint	3	120	40	100
RRPMs maint	3	102	34	100
Edge marker posts maint	2	20	10	0
Signs maint	1	1	1	0
Road works	3	300	100	0
other	3	770	257	0
Average	**130**	**36**	**36**	**49**

Safety Risk Weightings Comparrison with National Results

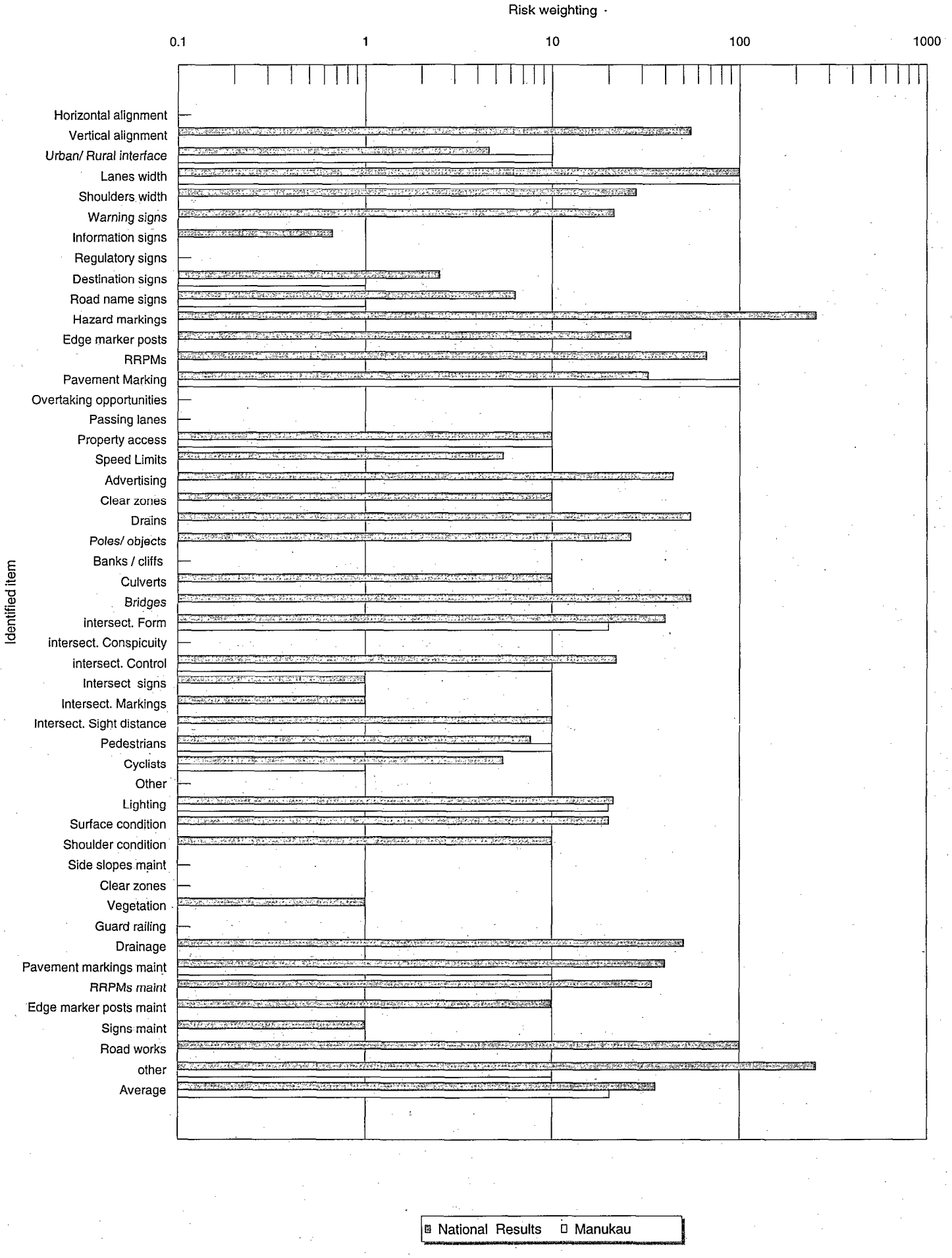
Christchurch



	National Results			Manukau
	total items	Total RW	Av. RW	RW
Horizontal alignment	0	0	ERR	0
Vertical alignment	2	110	55	0
Urban/ Rural interface	5	23	5	10
Lanes width	1	100	100	100
Shoulders width	4	112	28	0
Warning signs	8	170	21	0
Information signs	3	2	1	0
Regulatory signs	0	0	ERR	0
Destination signs	6	15	3	1
Road name signs	5	32	6	1
Hazard markings	3	770	257	0
Edge marker posts	5	131	26	0
RRPMs	3	201	67	0
Pavement Marking	4	130	33	100
Overtaking opportunities	0	0	ERR	0
Passing lanes	0	0	ERR	0
Property access	2	20	10	10
Speed Limits	2	11	6	0
Advertising	5	221	44	0
Clear zones	1	10	10	0
Drains	2	110	55	0
Poles/ objects	5	131	26	0
Banks / cliffs	0	0	ERR	0
Culverts	2	20	10	0
Bridges	2	110	55	0
intersect. Form	6	241	40	20
intersect. Conspicuity	0	0	ERR	0
intersect. Control	6	132	22	10
Intersect signs	3	3	1	0
Intersect. Markings	1	1	1	0
Intersect. Sight distance	2	20	10	0
Pedestrians	4	31	8	10
Cyclists	2	11	6	1
Other	0	0	ERR	0
Lighting	8	170	21	20
Surface condition	8	161	20	0
Shoulder condition	1	10	10	0
Side slopes maint	0	0	ERR	0
Clear zones	0	0	ERR	0
Vegetation	2	2	1	0
Guard railing	0	0	ERR	0
Drainage	2	101	51	0
Pavement markings maint	3	120	40	10
RRPMs maint	3	102	34	0
Edge marker posts maint	2	20	10	0
Signs maint	1	1	1	0
Road works	3	300	100	0
other	3	770	257	10
Average	**130**	**36**	**36**	**20**

Safety Risk Weightings Comparrison with National Results

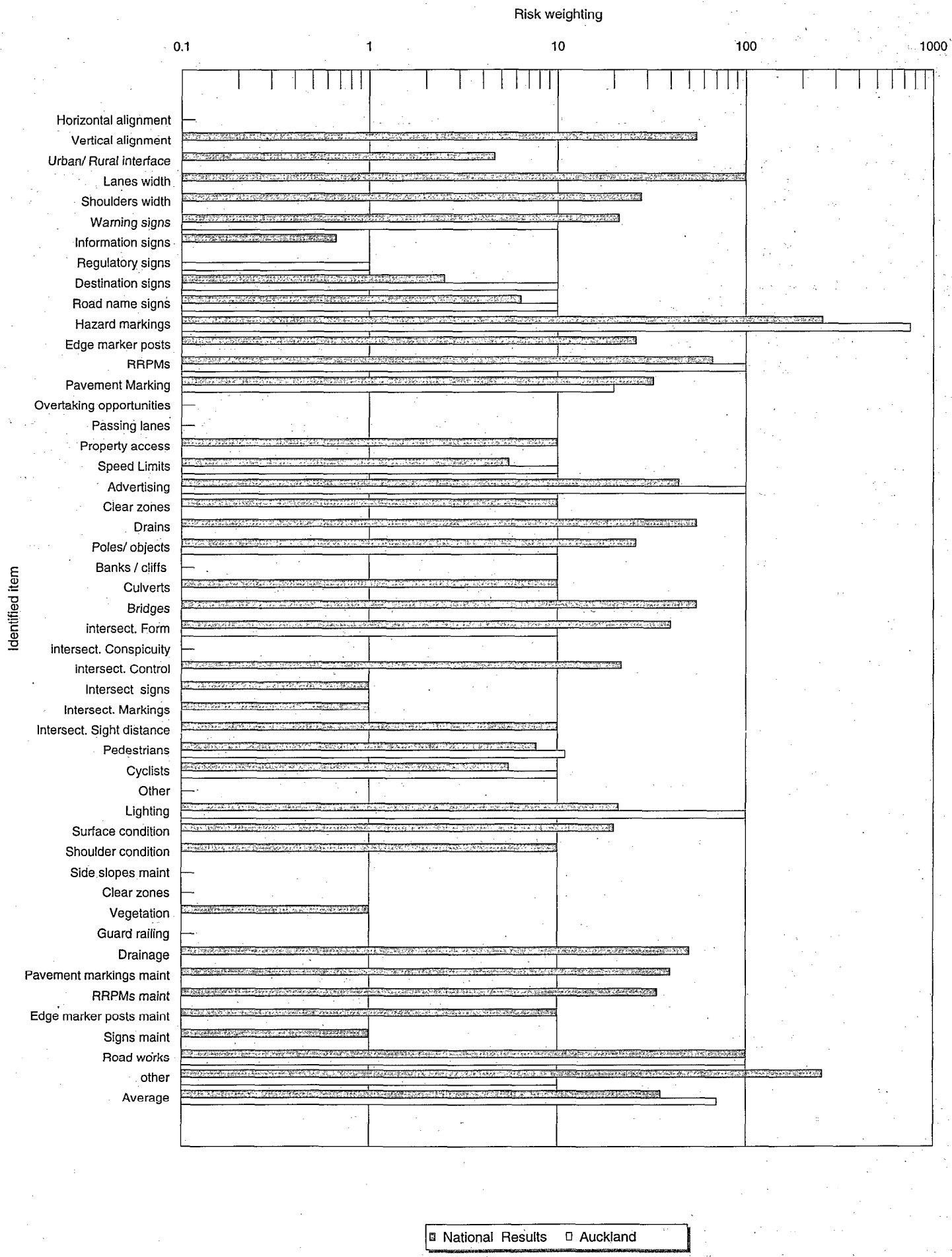
Manukau



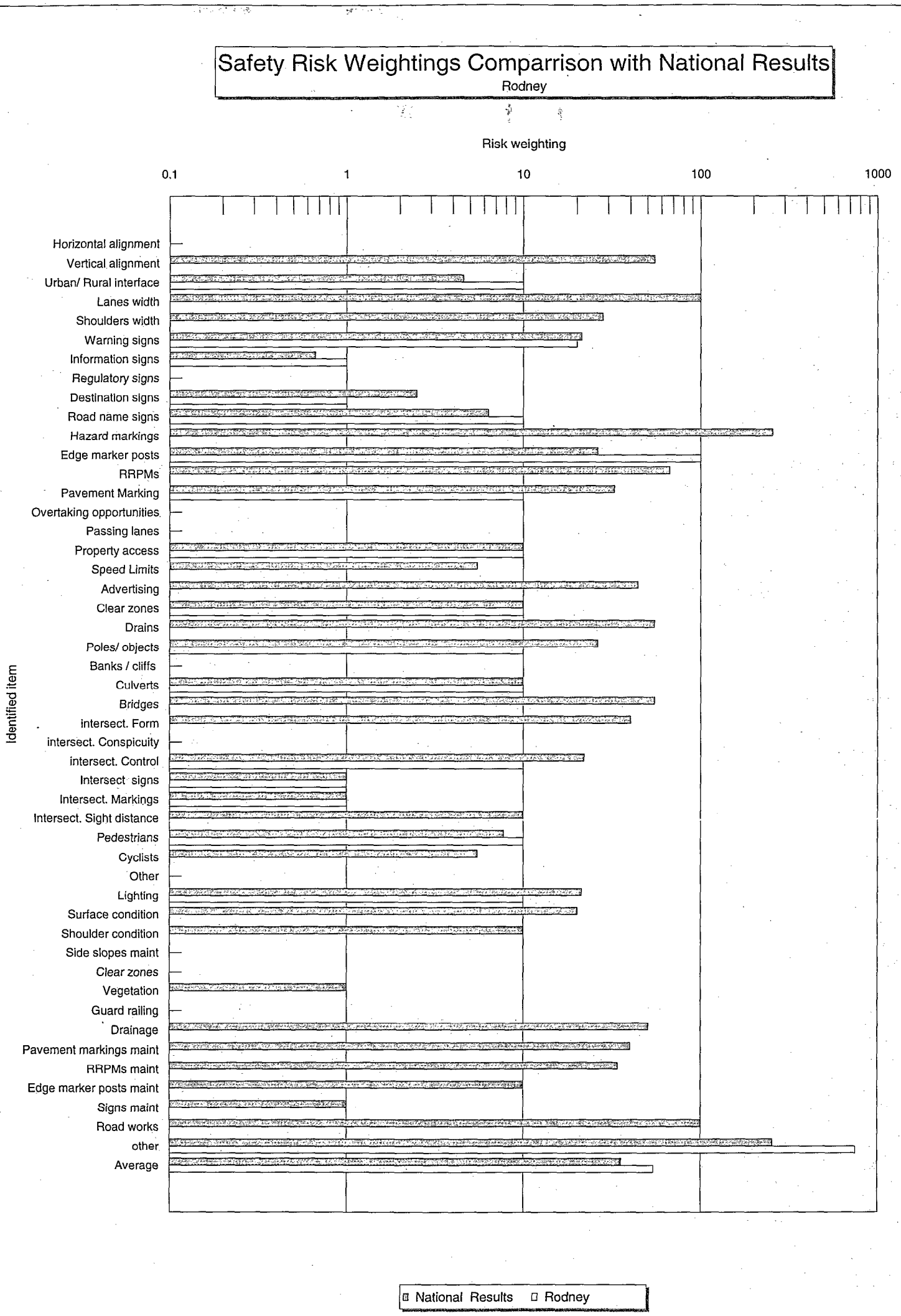
	National Results			Auckland
	total items	Total RW	Av. RW	RW
Horizontal alignment	0	0	ERR	0
Vertical alignment	2	110	55	0
Urban/ Rural interface	5	23	5	0
Lanes width	1	100	100	0
Shoulders width	4	112	28	0
Warning signs	8	170	21	10
Information signs	3	2	1	0
Regulatory signs	0	0	ERR	1
Destination signs	6	15	3	10
Road name signs	5	32	6	10
Hazard markings	3	770	257	750
Edge marker posts	5	131	26	0
RRPMs	3	201	67	100
Pavement Marking	4	130	33	20
Overtaking opportunities	0	0	ERR	0
Passing lanes	0	0	ERR	0
Property access	2	20	10	0
Speed Limits	2	11	6	10
Advertising	5	221	44	100
Clear zones	1	10	10	0
Drains	2	110	55	0
Poles/ objects	5	131	26	10
Banks / cliffs	0	0	ERR	0
Culverts	2	20	10	0
Bridges	2	110	55	0
intersect. Form	6	241	40	10
intersect. Conspicuity	0	0	ERR	0
intersect. Control	6	132	22	0
Intersect signs	3	3	1	0
Intersect. Markings	1	1	1	0
Intersect. Sight distance	2	20	10	0
Pedestrians	4	31	8	11
Cyclists	2	11	6	10
Other	0	0	ERR	0
Lighting	8	170	21	100
Surface condition	8	161	20	0
Shoulder condition	1	10	10	0
Side slopes maint	0	0	ERR	0
Clear zones	0	0	ERR	0
Vegetation	2	2	1	0
Guard railing	0	0	ERR	0
Drainage	2	101	51	0
Pavement markings maint	3	120	40	0
RRPMs maint	3	102	34	0
Edge marker posts maint	2	20	10	0
Signs maint	1	1	1	0
Road works	3	300	100	100
other	3	770	257	10
Average	**130**	**36**	**36**	**70**

Safety Risk Weightings Comparrison with National Results

Auckland



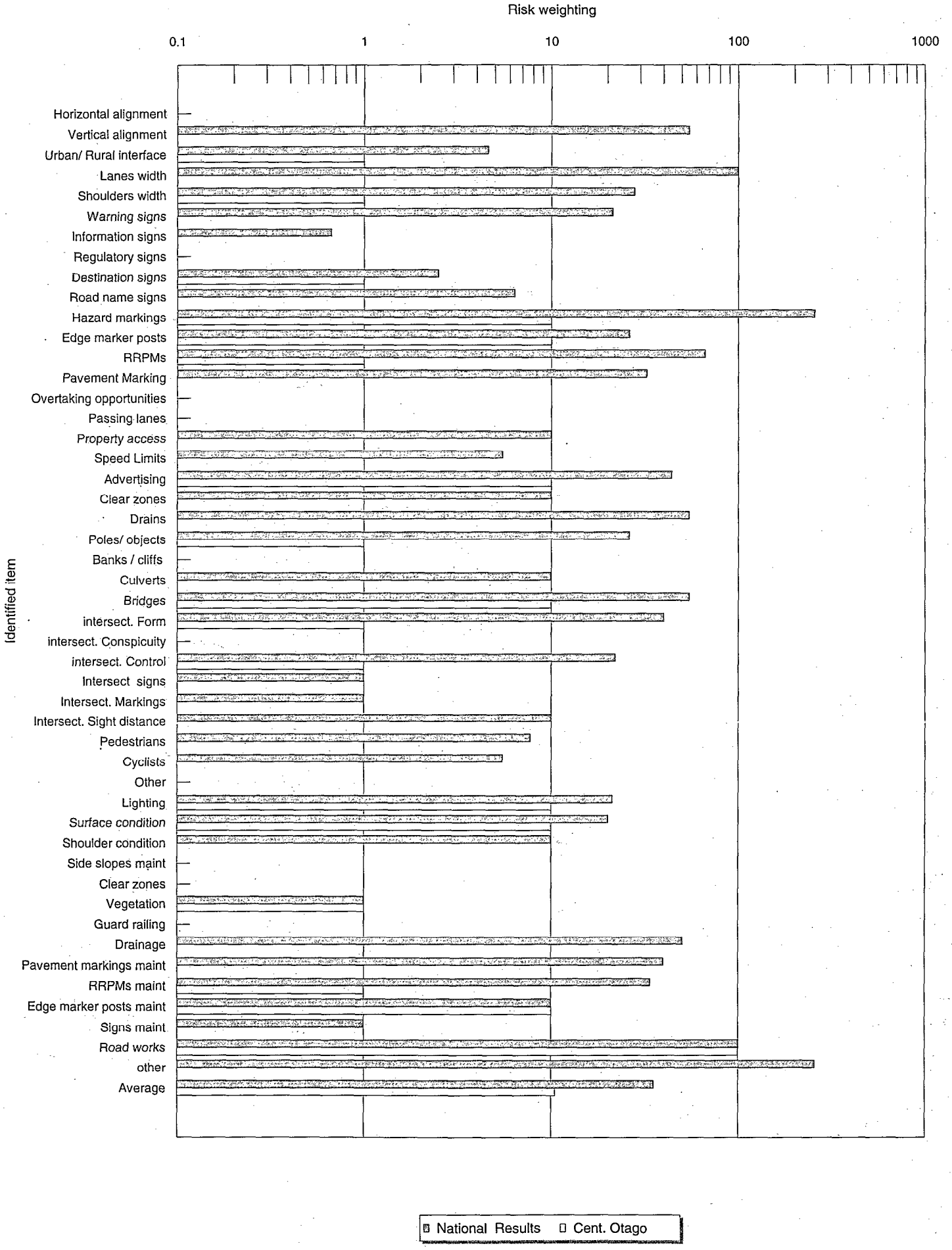
	National Results			Rodney
	total items	Total RW	Av. RW	RW
Horizontal alignment	0	0	ERR	0
Vertical alignment	2	110	55	0
Urban/ Rural interface	5	23	5	10
Lanes width	1	100	100	0
Shoulders width	4	112	28	0
Warning signs	8	170	21	20
Information signs	3	2	1	1
Regulatory signs	0	0	ERR	0
Destination signs	6	15	3	1
Road name signs	5	32	6	10
Hazard markings	3	770	257	0
Edge marker posts	5	131	26	100
RRPMs	3	201	67	0
Pavement Marking	4	130	33	10
Overtaking opportunities	0	0	ERR	0
Passing lanes	0	0	ERR	0
Property access	2	20	10	10
Speed Limits	2	11	6	0
Advertising	5	221	44	0
Clear zones	1	10	10	10
Drains	2	110	55	0
Poles/ objects	5	131	26	10
Banks / cliffs	0	0	ERR	0
Culverts	2	20	10	10
Bridges	2	110	55	0
intersect. Form	6	241	40	0
intersect. Conspicuity	0	0	ERR	0
intersect. Control	6	132	22	10
Intersect signs	3	3	1	1
Intersect. Markings	1	1	1	1
Intersect. Sight distance	2	20	10	0
Pedestrians	4	31	8	10
Cyclists	2	11	6	0
Other	0	0	ERR	0
Lighting	8	170	21	10
Surface condition	8	161	20	0
Shoulder condition	1	10	10	0
Side slopes maint	0	0	ERR	0
Clear zones	0	0	ERR	0
Vegetation	2	2	1	0
Guard railing	0	0	ERR	0
Drainage	2	101	51	0
Pavement markings maint	3	120	40	0
RRPMs maint	3	102	34	0
Edge marker posts maint	2	20	10	0
Signs maint	1	1	1	0
Road works	3	300	100	0
other	3	770	257	750
Average	**130**	**36**	**36**	**54**


Safety Risk Weightings Comparrison with National Results
Rodney
Risk weighting
0.1
1
10
100
1000
Identified item
Horizontal alignment
Vertical alignment
Urban/ Rural interface
Lanes width
Shoulders width
Warning signs
Information signs
Regulatory signs
Destination signs
Road name signs
Hazard markings
Edge marker posts
RRPMs
Pavement Marking
Overtaking opportunities
Passing lanes
Property access
Speed Limits
Advertising
Clear zones
Drains
Poles/ objects
Banks / cliffs
Culverts
Bridges
intersect. Form
intersect. Conspicuity
intersect. Control
Intersect signs
Intersect. Markings
Intersect. Sight distance
Pedestrians
Cyclists
Other
Lighting
Surface condition
Shoulder condition
Side slopes maint
Clear zones
Vegetation
Guard railing
Drainage
Pavement markings maint
RRPMs maint
Edge marker posts maint
Signs maint
Road works
other
Average
National Results
Rodney

	National Results			Cent. Otago
	total items	Total RW	Av. RW	RW
Horizontal alignment	0	0	ERR	0
Vertical alignment	2	110	55	0
Urban/ Rural interface	5	23	5	1
Lanes width	1	100	100	0
Shoulders width	4	112	28	1
Warning signs	8	170	21	0
Information signs	3	2	1	0
Regulatory signs	0	0	ERR	0
Destination signs	6	15	3	1
Road name signs	5	32	6	0
Hazard markings	3	770	257	10
Edge marker posts	5	131	26	10
RRPMs	3	201	67	1
Pavement Marking	4	130	33	0
Overtaking opportunities	0	0	ERR	0
Passing lanes	0	0	ERR	0
Property access	2	20	10	0
Speed Limits	2	11	6	0
Advertising	5	221	44	10
Clear zones	1	10	10	0
Drains	2	110	55	0
Poles/ objects	5	131	26	1
Banks / cliffs	0	0	ERR	0
Culverts	2	20	10	0
Bridges	2	110	55	10
intersect. Form	6	241	40	1
intersect. Conspicuity	0	0	ERR	0
intersect. Control	6	132	22	1
Intersect signs	3	3	1	0
Intersect. Markings	1	1	1	0
Intersect. Sight distance	2	20	10	0
Pedestrians	4	31	8	0
Cyclists	2	11	6	0
Other	0	0	ERR	0
Lighting	8	170	21	10
Surface condition	8	161	20	10
Shoulder condition	1	10	10	0
Side slopes maint	0	0	ERR	0
Clear zones	0	0	ERR	0
Vegetation	2	2	1	1
Guard railing	0	0	ERR	0
Drainage	2	101	51	0
Pavement markings maint	3	120	40	0
RRPMs maint	3	102	34	1
Edge marker posts maint	2	20	10	10
Signs maint	1	1	1	0
Road works	3	300	100	100
other	3	770	257	0
Average	**130**	**36**	**36**	**11**

Safety Risk Weightings Comparrison with National Results

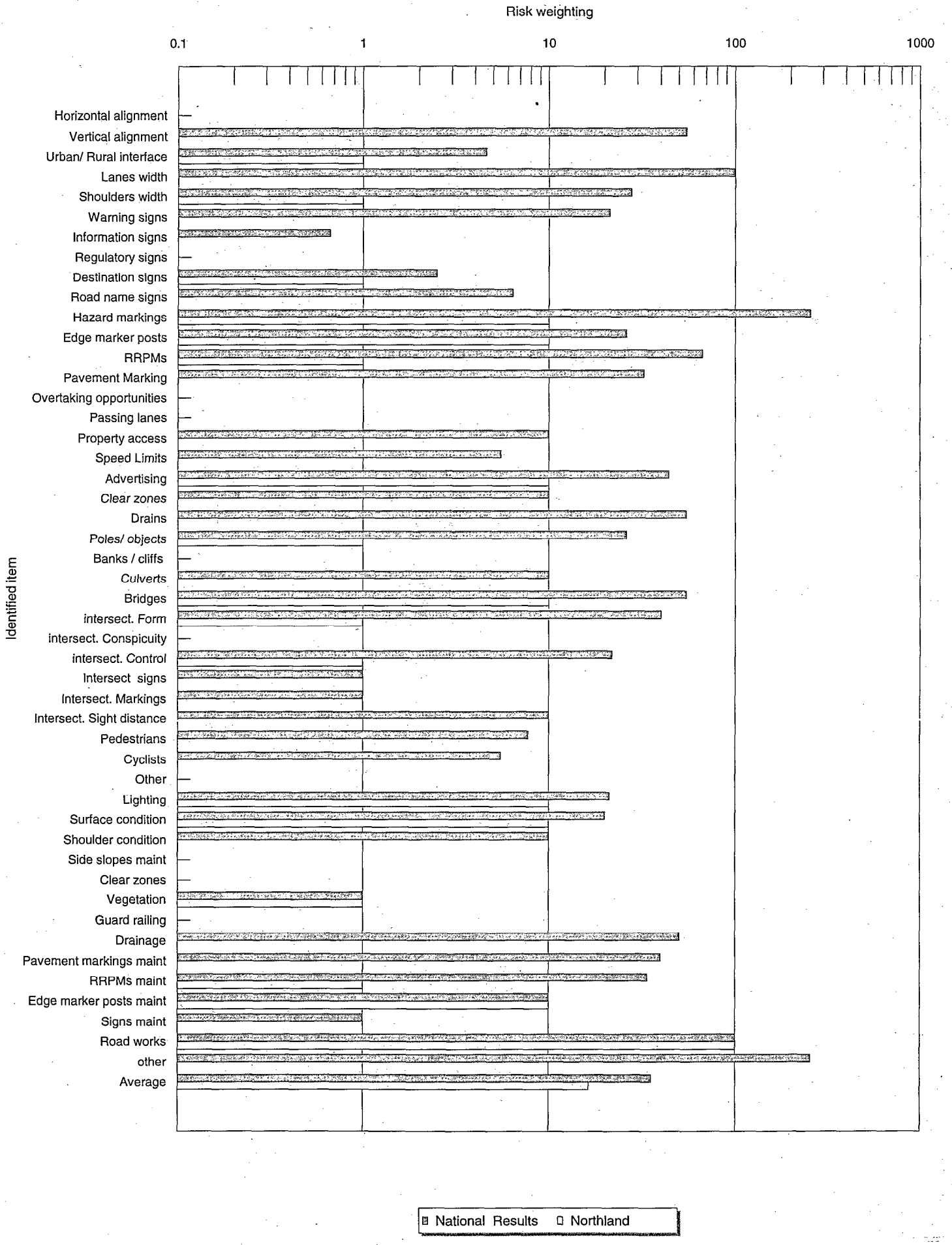
Cent. Otago



	National Results			Northland
	total items	Total RW	Av. RW	RW
Horizontal alignment	0	0	ERR	0
Vertical alignment	2	110	55	0
Urban/ Rural interface	5	23	5	1
Lanes width	1	100	100	0
Shoulders width	4	112	28	1
Warning signs	8	170	21	0
Information signs	3	2	1	0
Regulatory signs	0	0	ERR	0
Destination signs	6	15	3	1
Road name signs	5	32	6	0
Hazard markings	3	770	257	10
Edge marker posts	5	131	26	10
RRPMs	3	201	67	1
Pavement Marking	4	130	33	0
Overtaking opportunities	0	0	ERR	0
Passing lanes	0	0	ERR	0
Property access	2	20	10	0
Speed Limits	2	11	6	0
Advertising	5	221	44	10
Clear zones	1	10	10	0
Drains	2	110	55	0
Poles/ objects	5	131	26	1
Banks / cliffs	0	0	ERR	0
Culverts	2	20	10	0
Bridges	2	110	55	10
Intersect. Form	6	241	40	1
intersect. Conspicuity	0	0	ERR	0
intersect. Control	6	132	22	1
Intersect signs	3	3	1	0
Intersect. Markings	1	1	1	0
Intersect. Sight distance	2	20	10	0
Pedestrians	4	31	8	0
Cyclists	2	11	6	0
Other	0	0	ERR	0
Lighting	8	170	21	10
Surface condition	8	161	20	10
Shoulder condition	1	10	10	0
Side slopes maint	0	0	ERR	0
Clear zones	0	0	ERR	0
Vegetation	2	2	1	1
Guard railing	0	0	ERR	0
Drainage	2	101	51	0
Pavement markings maint	3	120	40	0
RRPMs maint	3	102	34	1
Edge marker posts maint	2	20	10	10
Signs maint	1	1	1	0
Road works	3	300	100	100
other	3	770	257	0
Average	**130**	**36**	**36**	**16**

Safety Risk Weightings Comparrison with National Results

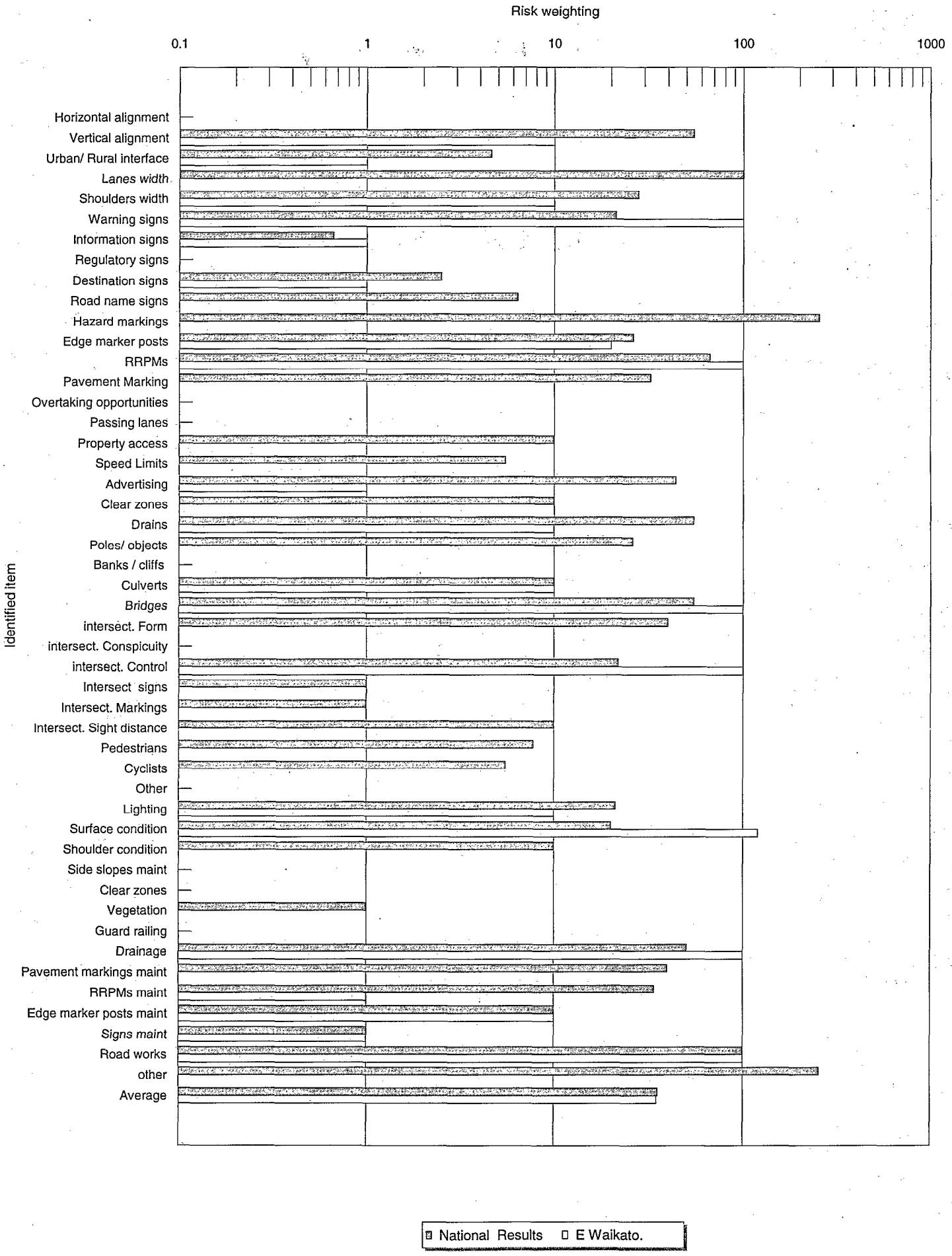
Northland



	National Results			E Waikato.
	total items	Total RW	Av. RW	RW
Horizontal alignment	0	0	ERR	0
Vertical alignment	2	110	55	10
Urban/ Rural interface	5	23	5	1
Lanes width	1	100	100	0
Shoulders width	4	112	28	10
Warning signs	8	170	21	100
Information signs	3	2	1	1
Regulatory signs	0	0	ERR	0
Destination signs	6	15	3	1
Road name signs	5	32	6	0
Hazard markings	3	770	257	0
Edge marker posts	5	131	26	20
RRPMs	3	201	67	100
Pavement Marking	4	130	33	0
Overtaking opportunities	0	0	ERR	0
Passing lanes	0	0	ERR	0
Property access	2	20	10	0
Speed Limits	2	11	6	0
Advertising	5	221	44	1
Clear zones	1	10	10	0
Drains	2	110	55	10
Poles/ objects	5	131	26	0
Banks / cliffs	0	0	ERR	0
Culverts	2	20	10	10
Bridges	2	110	55	100
intersect. Form	6	241	40	0
intersect. Conspicuity	0	0	ERR	0
intersect. Control	6	132	22	100
Intersect signs	3	3	1	0
Intersect. Markings	1	1	1	0
Intersect. Sight distance	2	20	10	0
Pedestrians	4	31	8	0
Cyclists	2	11	6	0
Other	0	0	ERR	0
Lighting	8	170	21	10
Surface condition	8	161	20	120
Shoulder condition	1	10	10	0
Side slopes maint	0	0	ERR	0
Clear zones	0	0	ERR	0
Vegetation	2	2	1	0
Guard railing	0	0	ERR	0
Drainage	2	101	51	100
Pavement markings maint	3	120	40	0
RRPMs maint	3	102	34	1
Edge marker posts maint	2	20	10	10
Signs maint	1	1	1	1
Road works	3	300	100	100
other	3	770	257	0
Average	**130**	**36**	**36**	**35**

Safety Risk Weightings Comparrison with National Results

E Waikato.



APPENDIX E- Procedure to Determine Performance Measures for Safety Audits on Existing Roads

Procedures to determine Safety performance measures for Safety Audits on Existing Roads

Safety performance measures for safety audits on existing roads are intended for use on the 3 day road controlling authority audits undertaken by Transfund New Zealand Review and Audit Division. They are not calibrated to be used on any other safety audit. The Safety Performance Index should not be applied to sections, lengths or urban and rural splits within a safety audit. The Safety Performance Index is calculated as follows:

1. Complete the *attached* worksheet "Safety Audits on Existing Roads : Risk Weighting, Calculation Sheet".

   Please note the following when completing the worksheet.

   a) More than one problem may be recorded for each item on the worksheet list. For example, there may be two or more problems relating to warning signs, each occurrence should be recorded.

   b) Record only general problems identified in the Safety Audit Report. Care should be taken that **problems** rather than the recommendations are identified.

   c) Provide a cross reference to the report from each item on the worksheet.

   d) Risk levels are determined in the safety audit report as per the method defined in "Safety Audit of Existing Roads, Draft Procedures", Feb 1996 Appendix III : Risk Level Assessment for Inappropriate Standards.

   e) Provide short reference notes, defining problem, or recommendation.

2. Allocate a risk weighting for each item on the worksheet using the following table:

Risk	Low	Medium	High	Urgent
Risk Weighting (RW)	1	10	100	750

   If more than one safety problem is identified per item (as described in 1a) calculate the additional risk score as appropriate ie. 2 x medium = 20 points.
   Sum the number of problems identified and the risk wieghtings ($\sum$RW) at the base of the worksheet.

3. Calculate the safety performance index SPI as follows:

$$SPI=[\sum RW].E$$

Exposure E is the amount of time an audit team is exposed to a road. Exposure is to be taken as E= 1.00 for Transfund New Zealand safety audits on existing roads. Further exposures may be determined for urban/rural splits or shorter audit periods as the database of safety audit reports increases.

The Safety Performance Index is a score from which a road controlling authority can monitor its performance on successive audits or against national results and trends.

4. Calculate the Safety Performance ratio as follows:

$$SPR=\frac{SPI}{675}$$

SPR values above 1.00 indicate a poorer than average performance. Values less than 1.00 indicate a better than average performance.

The safety performance ratio is a method of directly gauging the performance of a road controlling authority against other authorities that have been audited.

5. The following cautionary notes should be considered in applying these performance measures:

a) The identification of problems and assessment of risk for each audit is subject to the personal opinions and experience of individual safety audit teams. The teams vary from safety audit to safety audit. Thus the assessment of problems and risk may not be consistent from report to report.

b) The initial sample size of seven reports is small, a larger number of reports will enable more accurate results to be determined. However, the safety performance ratios will always be expressed in terms of 1.00 being the average value and results for safety performance index will be monitored and published annually.

6. Please provide feed back on the use of the Safety Performance Index sheets to:

Dr Ian Appleton
Transfund NZ
Wellington

The process will be revised to include a larger database as reports become available.

Safety Audit on Existing Roads: Risk Weighting Calculation Sheet

Authority: Date

			Reference	Risk Level	Risk Weighting	Notes
1	Alignment / Environment	Horizontal				
		Vertical				
		Urban/ Rural interface				
2	Pavement Width	Lanes				
		Shoulders				
3	Delineation	Warning signs				
		Information signs				
		Reglatory signs				
		Destination signs				
		Road name signs				
		Hazard markings				
		Edge marker posts				
		RRPMs				
		Pavement Marking				
4	Level of Service	Overtaking opportunities				
		Passing lanes				
		Property access				
		Speed Limits				
5	Road Side Hazards	Advertising				
		Clear zones				
		Drains				
		Poles/ objects				
		Banks / cliffs				
		Culverts				
		Bridges				
6	Intersections	Form				
		Conspicuity				
		Control				
		Traffic signs				
		Markings				
		Sight distance				
7	Road users	Pedestrians				
		Cyclists				
		Other				
8	lighting					
9	Maintenance / General Works	Surface condition				
		Shoulder condition				
		Side slopes				
		Clear zones				
		Vegetation				
		Guard railing				
		Drainage				
10	Maintenance/ signs and markings	Pavement markings				
		RRPMs				
		Edge marker posts				
		Signs				
11	Road works					
13	Others: special					
		Total Risk Weighting (RW)				

PEER REVIEW OF THE DISCUSSION DOCUMENT

"DEVELOPMENT OF A SAFETY PERFORMANCE INDEX FOR SAFETY AUDITS ON EXISTING ROADS"

Undertaken for Transfund New Zealand

By Ian Bone and Stephen Hewitt,
Beca Carter Hollings and Ferner Ltd.,
Auckland

July 1997

REVIEW OF THE DICUSSION DOCUMENT FOR DEVELOPMENT OF A SAFETY PERFORMANCE INDEX FOR SAFETY AUDITS IN EXISTING ROADS

25 July 1997

1 Brief

A review was requested with particular reference to the weighting process for the Safety Performance Index (SPI) recommended in the Discussion Document, February 1997. From previous discussions a concern had been expressed that the urgent category risk levels could have an overwhelming affect on the SPI out of proportion to their true social cost. There is also the possibility that in promulgating a SPI, the performance of a road controlling authority may be unjustifiably rated lower or higher if the weightings contain bias, and that an inappropriate allocation of funding of safety remedial works may result. Our review to the Discussion Document has been outlined below, with a summary of our conclusions provided at the end of this report.

2 The Proposed Safety Performance Index

The SPI is based on the weighted sum of the safety problems identified in a safety audit report multiplied by an assessed level of risk attributed to each problem. This is further weighted by a measure of effort applied to the audit, defined as the amount of time spent on it, described as the "exposure" of the area covered in the audit to efforts of the audit team.

2.1 The Risk Weighting

The risk associated with a safety problem is graded into four levels - low, medium, high and urgent. The gradings are defined by a combination of the severity of the outcome should a crash occur (hazard severity) and the probability of occurrence (hazard probability). Essentially this is a form of "expected value" of the safety costs of the problem. Combinations of hazard probability and severity should give a similar expected cost if the grading is to be consistent. *Then there is the question of whether*

the grading scale is linear - are the increments from low to urgent in equal steps ?

2.2 Hazard Probability Scale

The frequency defining hazard probability is expressed as "likely to occur within a time period" (1 year, 5 years, 10 years) or an "interval between occurrences" (7 to 10 years) or "unlikely ever to be experienced". This presents a rather strange mixed scale. It can be reduced to a probabilities as follows if we interpret likelihood as a greater than 50% probability of occurrence:

- frequent: >50% probability of < 1 year interval between occurrences
- probable: >50% probability of < 5 year interval, but not >50% probability of < 1 year interval
- occasional: >50% probability of <10 year interval but not > 50% probability of < 5 year interval
- remote: return period of between 7 and 10 years - say 8.5 expected return period but not >50% probability of <10 year interval
- improbable: return period greater than 10 years - undefined.

The actual probability distribution of occurrences of the safety problem will obviously affect the interpretation of this scale. The distinction between occasional and remote appears questionable - once in 20 or 25 years would seem to be more in keeping with the scale.

It would be preferable to use a scale which could be more precisely related to the crash history of the site or problem being treated.

2.3 Hazard Severity Scale

The severity scale can similarly be interpreted in numerical terms, using the PEM accident costs:

- Catastrophic- multiple fatalities. There is data to identify the number of fatalities and other injuries which occur on average for a multiple fatality. For catastrophic that is >50% probability of an accident cost of $4.0 million or greater
- Critical - likely to cause a fatality A >50% probability of a cost of $2 million or more but not as much as catastrophic.
- Major - could possibly cause a fatality. A <50% probability of a cost of $2 million or more but a >50% probability of a cost of $0.25 million (serious injury).

- Minor - a < 50% probability of a cost of > $0.25 million
- Negligible - a << 50% probability of a cost of > $0.25 million

A more basic concern with the hazard severity scale lies in the way the ratings are described. There is the set of conditions which give rise to the crash, and then there is the severity outcome. For example, if a safety problem is likely to lead to vehicles losing control and leaving the road, then there is a probability distribution of injury severity associated with this form of crash. In particular, it will be very difficult to distinguish between situations likely to cause multiple fatalities compared with those likely to cause a single fatality - this is more likely a result of the number of vehicle occupants and chance. The way in which "likely" is interpreted could show wide variation. It is also unclear whether safety auditors may be inclined raise the severity rating in response to the number of crashes - multiple fatalities from several crashes or multiple fatalities from a single crash.

We think that the wording of this scale should be reviewed with the aim of giving a clear gradation of severity in terms of social cost (an approximate ratio of 100:10:1 between fatal, serious and minor injury). It may be necessary to change the "catastrophic" category to "will most probably cause fatalities" rather than refer to multiple fatalities at all, and also to put some numeric probabilities alongside the written descriptions.

2.4 Cost Matrix

If we form a crude cost matrix from the above, using assumed centre values for each classification, we get the following table of expected value of cost per year.

Expected Value of Crash Costs

Severity	Probability - mean number per year				
	Frequent 2 ?	Probable 0.33	Occasional 0.17	Remote 0.12	Improbable 0.02 ?
Catastrophic, $5M	10	1.65	0.85	0.6	0.1
Critical $3M	6	1	0.5	0.36	0.06
Major $1M	2	0.33	0.17	0.12	0.02
Minor $0.1M	0.2	0.033	0.017	0.012	0.002
Negligible $0.01M	0.02	0.0033	0.0017	0.0012	0.0002

		Range	Mean	Ratio	x Interval
Urgent		10	10	3333	6.6
High		0.2 - 6	1.5	500	15
Medium		0.0033 - 0.66	0.1	33	33
Low		0.0002 - 0.12	0.003	1	

The values within each shaded region should be broadly similar if the cost and

frequency weightings are correctly identified. The scale is clearly non-linear, but is not geometric or logarithmic either as the multiplicative intervals show.

On this basis, the categories should perhaps be redefined as shown below:

Proposed Revised Risk Categories

Severity	Probability - mean number per year				
	Frequent 2 ?	Probable 0.33	Occasional 0.17	Remote 0.12	Improbable 0.02 ?
Catastrophic, $5M					0.1
Critical $3M				0.36	0.06
Major $1M		0.33	0.17	0.12	0.02
Minor $0.1M	0.2	0.033	0.017	0.012	0.002
Negligible $0.01M	0.02				

		Range	Mean	x Interval
Urgent		>$5m	7.5	5.7
High		$0.5-5.0m	1.3	6.5
Medium		$0.1-0.5m	0.2	8
Low		$0.01 - 0.1m	0.025	15
Negligible		< $0.01m	0.0017	1

A more detailed and careful analysis would be needed to firm up on a new classification, but it does seem as though the proposed risk categories need review. The hazard probability and hazard descriptions probably should also be more closely defined.

The discussion document tested risk weightings of various scales from 1/2/5/10 (A) to 1/10/100/1000 (G). The above analysis indicates that ranking G, 1/10/100/1000 should provide the closer fit to social costs as defined by the value of statistical life currently in use as there is a factor of 1000 in the difference in social costs between the high and low category. However, the scale as suggested is in need of some refinement.

2.5 Exposure

Exposure has a very clear and widely understood definition in safety analysis. We do not see the need to cloud the issue with using the term in this other context. Another description such as "audit effort" or "audit intensity" could be considered. As the exposure weighting is not actually used, it is difficult to judge whether it is worthwhile.

With diminishing returns, it may be thought that the benefits of safety audits would progressively reduce as safety problems are eliminated. This effect does not seem to be anticipated in the discussion paper.

2.6 Traffic Volume Effects and SPI

On Page 12 of the discussion paper, it is noted that the procedure does not take account of traffic volume. That is, the urgency of a safety problem is related to the risk of occurrence and severity of a particular type of problem but is not necessarily weighted to reflect the higher exposure on higher volume roads.

This seems extraordinary. The method should take account of the traffic volume in the hazard probability or be amended to do so.

2.7 Terrain and Other Geographical Differences

We do not see why this should be a problem if the traffic volume effects are taken into account. Where severity outcomes vary with terrain or other road features, then this should surely be reflected in the hazard severity or probability ratings.

3 Conclusions

A general conclusion is that there is quite a high degree of subjectivity in the process of developing a SPI as described, and that some of this could be minimised if definitions are tightened up and there is less room for varying interpretation. At present we do not feel that sufficient confidence can be put in the method for it to be used as a guide in comparing road controlling authorities or allocating resources to safety improvements.

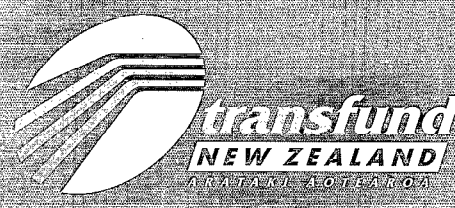
Specific conclusions to the discussion document are:

1. The hazard severity scale needs to be more clearly defined;
2. The hazard probability scale also needs to be more clearly defined in terms of probability of occurrence; the remote probability category should be reconsidered;
3. The cross-classification of the four severities Urgent, High, Medium and Low should be reconsidered;
4. Scale G, 1/10/100/1000 is probably of the right order but the interval costs need to be matched more carefully with the cell ranges of expected value in the cross-classification. Scale F probably does not have a wide enough spread and the other scales should have been non-starters.
5. A fifth category, Negligible or Very Low could possibly be added.
6. The term "exposure" should not be used in the context described in the paper
7. Traffic volume or other appropriate safety exposure weightings should be incorporated into the index, most likely through the hazard probability rating. Guidelines should allow for this, as this will be helpful in distinguishing between

urban and rural councils.

8. There are some ramification of this process that are of great concerns. It is assumed that Transfund would use this procedure to assess how well it is spending its money on the current roading asset. The process could result in a Council being unfairly rated poorly compared to other Councils by an audit team, due to only auditing a small section of the Council's roading network. This process could also reflect badly on the performance of the Council's officer in change of Roading,where it is not warrented. Thesubjectivety of this process need to be limited for the process to be effected as a tool for compare Council roading networks.

9. As a final comment the discussion document does not take into account good practices undertaken by a Council. The procedures should give credit to a pro-active Council.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